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FOREWORD

This volume marks the beginning of the third series of PROCEEDINGS OF THE ROYAL CANADIAN INSTITUTE. The two previous series were devoted largely to articles recording the results of research in the various branches of science and have been replaced by the Institute's Transactions.

The third series of Proceedings of which this is the first volume will furnish to members a record of the lectures delivered before the Royal Canadian Institute. The present volume deals with those delivered during the year 1935-36.

In two instances it has been possible to print the lecture in full. In the case of others, summaries or abstracts are given which, it is hoped, will be found to contain the most important points of the lectures. The summaries have, in many cases, been prepared by the lecturers themselves or have been approved by them. In the case of a few lectures it has not been possible to arrange for this; to make the record as complete as possible shorter abstracts of these have been included.

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THE MINERALS THAT SURROUND US

J. Ellis Thompson

When casting about in my mind for an introduction to this address, I rather naturally decided to call to my aid that most prolific of the metred writers who rejoices in the cognomen of anon. His effusion will be mercifully short, after which we shall proceed without further preamble to the subject itself.

By what are we surrounded?
By air and land and sea.
Of what are they compounded,
As far as we can see?

Of elemental forces,
Of atoms and the like,
From elemental sources
That never go on strike.

And when these tiny atoms,
That are so very small,
Like microscopic phantoms
Responding to a call,

Are laid in rows so even,
With no atomic squeak,
Those things you'll be receiving
Of which I wish to speak.

Pursuing the imagery of our poetic friend, though not too closely, we are surrounded by the three elements, air, land, and water. With the first of these three we are not concerned this evening. Of the other two I shall speak at some length about one, and shall pass over the other with such brief mention as is in accord with its painful treatment of me on many occasions in the past. We may dismiss the water part of our surroundings with the assertion that water is a mineral pure and simple, and that even a goodly portion of the impurities in it are mineral salts. But, except under rather special circumstances when we are crossing a body

of water, our immediate surroundings are terrestrial. Let us consider, then, the nature of the land surface about us. If we leave to one side the organic part, with its sub-divisions of animal and vegetable and their no less important synthetic by-products, and turn our attention to the inorganic or what may be termed the fundamental part of our surroundings, we are confronted on every side by minerals or mineral products. If, then, they are part of our everyday surroundings, surely we should all know something about them. What, then, are minerals? Before attempting to answer this question, let me hark back for a moment to more fundamental considerations of the chemical content of this our land surface. Ninety-two chemical elements are known to exist in the earth's crust. Which one of these do you suppose is the commonest? Is it iron or copper? It is not a metal at all, but the gas oxygen. What comes next? A metal this time, but not one that you think of as common, much less the commonest of all. This is silicon. These two make up about 73% of the earth's crust. If to these you add the six metals, aluminium, iron, calcium, sodium, potassium, and magnesium, which are listed in the order of their prevalence, you have made up 98.58% of the earth's crust. It may surprise you to find that aluminium is ahead of iron in this list. We generally think of aluminium as one of the less common metals. This apparent anomaly will be explained later on in the lecture. You will have noticed also that such metals as copper, lead, zinc, nickel, and tin are of comparatively rare occurrence, while magnesium, potassium, and sodium are listed in the first eight. The first five are well known to us and are in common use in the arts and devices of man, but, if we know the last three at all, it is in the form of compounds used as medicaments, fertilizers, or condiments. The apparent paradox is explained by the unavailability as ores of the metals or as sources of their compounds, of many mineral compounds of magnesium, sodium, and potassium.

But to get back to our main thesis, what is a mineral, and how is it related to the chemical elements we have just mentioned? The term mineral is not an ancient one, having been used first in its present signicance in the latter part of the 18th century. Before that time, it was known variously as ore, metal, or fossil. At the present time, since the mine has been described as a hole in the ground owned by liars, and since the mine owes its very existence to the winning of valuable minerals from the earth's crust, it might be designated by disgruntled investors as the father of all lies. There have, of course, been many definitions of the term mineral. The best and simplest one that comes to my mind is this. A mineral is a natural, inorganic, homogeneous substance, having a definite chemical composition, definite physical properties, and, under

favourable circumstances, a definite geometric form. This, as I mentioned before, is the best and simplest definition. What must the others be like? Let us examine the limitations of this definition very briefly, using for purposes of illustration the common mineral, quartz. This substance was formed by nature's processes; it is homogeneous throughout its mass; it is made up of the two elements silicon, a metal, and oxygen, a gas, combined in fixed proportions; it has a very definite hardness, lustre, and other physical properties, and, as you can see, has a very beautiful geometric form. It is therefore properly called a mineral. So that we may become better acquainted with these creations of nature, let us examine their properties in some detail. Just as we get to know a man by his height, the colour of his eyes, the shade of his hair and possibly the abundance or lack of it, and by the company he keeps, so we may know the minerals by their hardness, lustre, type of breaking, geometric form, and common mineral associates, to mention but a few of their many properties. Some of these terms are very easy of explanation but others are more difficult. The kind of hardness that is used in this connection is a scratch hardness. Lustre has to do with the amount of light reflected from a surface of the mineral, and is generally likened to that of a common mineral such as metal, glass, pearl, resin, or the like. It has been found that minerals are very nearly as clannish as people in the associates they choose in their natural surroundings. The lead ore, galena, likes to live with the zinc one, sphalerite, while the two copper sulphides, chalcocite and bornite, seem to get along in perfect amity. such properties as geometric form and the different types of breaking in minerals are more difficult of elucidation. Since the latter depends upon the former, we will first discuss, very briefly, the geometric forms of minerals. To do this it is necessary to refer once more to the little atom mentioned at the start of this address in the "rhyme or doggerel or worse" of my poetical friend. To quote from the last stanza when they

> "Are laid in rows so even,
> With no atomic squeak"

these atoms, at least when conditions are favourable, are built up into regular geometric forms which we call crystals. It has been found that the growth of these crystals is governed very rigidly by certain definite mathematical laws. Now don't be alarmed. I have no intention of boring you with these laws. Suffice it to say that, with these laws as controlling factors, the different groups of chemical atoms are built up into regular geometric forms. It has been found, also, that these forms, which are limited in number, at least as to their general type, may be

conveniently classified according to the degree of their regularity or symmetry into six large classes or divisions with minor sub-divisions. These classes are generally called systems. These six systems are as follows: cubic, hexagonal, tetragonal, orthorhombic, monoclinic, triclinic, and they are arranged in the order from the isometric with the most symmetry, to the triclinic with the least. Each mineral species shows, under suitable conditions of growth, a characteristic crystal form. Fluorite, a compound of calcium and fluorine, when in good crystal form, always exhibits the isometric kind of symmetry. Microcline, on the other hand, never appears in anything but triclinic forms.

Coming next to the kinds of breaking in minerals, we have in general two kinds, cleavage and fracture. These may be likened, roughly, to the kinds of breaking you may see in a piece of wood. If the wood is split in one particular direction, the direction of growth of the tree, it breaks easily, and a smooth breaking-surface is produced. On the other hand, if it is broken in any direction other than this particular one, it breaks with difficulty and produces a rough breaking-surface. The first of these breakings is roughly similar to cleavage, and the second to fracture. Cleavage in a mineral, just as in the case of the wood, is always directly related to a direction or directions of growth, while fracture is independent of these directions.

But there are other peculiar properties of minerals, possessed only by a very few of them. Certain minerals are magnetic. By this we usually means that they are attracted by a magnet. It is very seldom the case that minerals are themselves natural magnets, although this property is sometimes shown by the mineral magnetite. But you will be interested to hear that certain iron compounds, such as magnetite, an oxide, and pyrrhotite, a sulphide, are attracted to the magnet, just as a piece of steel is. Those of you who have travelled by compass in the forested terrain of our north country may have had the distressing experience of seeing your compass do all sorts of strange tricks. This was undoubtedly due to the presence of some magnetic mineral in the vicinity acting on the magnetized needle of your compass. Another interesting property that is not at all common is the fluorescence of minerals. If you have travelled in the woods at night, or even in the twilight, you may have noticed a strange and unearthly spot of luminosity at your feet. On investigating this appears to come from a piece of rotten wood. We say it is phosphorescent. Now certain of the minerals exhibit much the same phenomenon but, as the mineral fluorite shows it very strongly, we call it fluorescence. What causes this strange phenomenon? We don't know for certain. Some people think it is caused by small amounts of impurity of a radio-active character. Whatever be the cause, we can

make the fluorite and a few other minerals show this property by peppering the mineral specimen with non-visible, short length light rays and in some mysterious way these are transmuted by the mineral to visible rays which make it glow just as the rotten wood did. But now you are thinking the lecturer has wandered off into the mists of pure science. There can surely be no practical application to such properties as magnetism and fluorescence. To show that your lecturer is guiltless of this charge, let me say that both magnetism and fluorescence find practical application in certain special phases of ore treatment.

We shall now suppose that we have become sufficiently familiar with the appearance of minerals to be able to identify them fairly well at sight. Where, then, may we look for them? Where are they found? The answer is, they are all about us wherever we go. If we live in the country we find them in the rocks and the soil that we walk on every day. If we live in the urban centres they are still not far to find, and a little work in the garden will turn up plenty of the soil and rather more of the rocks than is to our taste as gardeners. Let us examine these two things and see what their composition may be. Even a casual inspection of the rocks will reveal that they are composed of minerals, generally of two or more species which are visible to the naked eye, while the soil is observed to be so finely divided that other means of identification must be used. On inspecting the soil more closely, it is discovered that it also consists of minerals, and this tends to confirm our suspicion that it is closely related to the rocks. In actual fact soil is produced by the mechanical and chemical breakdown and decay of rocks. Of course some humus material is added from the decay of vegetable matter, but this is a minor constituent of soils which are primarily composed of minerals. What minerals, then, are commonly found in rocks and in the decayed rocks or soil? We may compile a very short list of these as follows: Quartz, orthoclase, plagioclase, hornblende, pyroxene, muscovite, biotite, olivine, chlorite, serpentine, kaolin, calcite, dolomite. The above list includes most of the more important minerals found in ordinary rocks or in the soil. How are these minerals arranged in the rocks and what is a rock anyway? How does it differ from the minerals themselves? A rock is an aggregation of minerals, generally, although not always, of two or more species, which makes up an appreciable proportion of the earth's crust. By what process of nature are rocks produced? First, by rapid or slow crystallization from a molten or fire solution generally called a magma, producing types called igneous rocks. These are gradually disintegrated by mechanical and chemical decay into fragmental material which is then sorted over by water action into deposits called sediments, consisting of pebbles, sand, mud, and limey material. These sediments may be compacted

later by the pressure of overlying material into the second type called sedimentary rocks. Finally, strains and stresses within the earth's crust may affect certain changes in the other two types, giving rise to the third type called metamorphic rocks. Let us examine very briefly one example of each of these three types. For the igneous rock let me pick you a granite, since most of you have already heard of this rock. Let me say that we are here using the term granite in its scientific, rather than in its popular, sense. Most stone-workers differentiate but two or three kinds of rocks and the one that is hard to manipulate is invariably called granite. The true granite is a coarse-grained rock composed mainly of quartz, orthoclase, and a third constituent which is either muscovite, biotite, or hornblende. It is called a muscovite, biotite, or hornblende granite according to which of the last three minerals is present. For the sedimentary class let me mention a sandstone. It is made up largely of grains of clear, glassy quartz cemented together. How did it get that way? Well, quartz is one of the minerals that is very resistant to change and, when any rock containing quartz breaks down, this mineral is generally left behind in the form of sand. You see it frequently along the lake or sea shore. If, then, successive cycles of erosion and sedimentation leave behind several layers of this sandy material, and if it be covered with other sediments or rocks, it is finally consolidated by pressure from above into the rock we call a sandstone. It may be mentioned in passing that of the other water-sorted sediments aggregates of boulders cemented together, produce rocks called conglomerates, while the muddy and limey deposits are compacted into rocks called shales and limestones respectively.

Finally, for our metamorphic series we must pick two examples since these rocks result from the change of both the igneous and the sedimentary types. As an example of a metamorphosed, igneous rock we shall select a rock that has at least a pleasant name—a gneiss. This is simply a changed granite, with the same mineral constituents as those in the granite, but with a slightly different arrangement of them. How do we know it has been changed or metamorphosed? Simply by the fact that the three original constituents of the granite have changed their positions so that they are now in parallel rows. This is especially noticeable in the case of biotite, the dark plates of this mineral showing in parallel or nearly parallel bands, in marked contrast to the two lighter-coloured minerals, orthoclase and quartz.

Now let us see what happens to our sedimentary rock, the sandstone, when it is metamorphosed. In this case we have, of course, a rock with the same mineral composition as sandstone, chiefly the mineral quartz,

but there is this difference. Whereas the sandstone consists of sand or quartz grains loosely held together by whatever cementing material was available, giving a rock that is rough and gritty to the feel, the quartzite, which is the name given to the metamorphosed sandstone, has the quartz grains closely bound together by a siliceous cement and the rock is comparatively smooth. In this case the parallel arrangement of the gneiss is seldom seen. The agents in this example of metamorphism are probably both heat and pressure and the closer cementing of the quartz grains, for lack of a better name, is called re-crystallization. Apparently what happens is that some at least of the siliceous material in this rock is chemically dissolved and then re-precipitated. The practical results of this process are seen in the closer binding of the mineral particles, occasionally also by an enlargement of them. But now, after disposing of the whole science of petrography in a few sentences, limits of time make it necessary for us to hurry on. While the great bulk of our minerals occur in rocks, we are generally much more interested in another rarer, but more economic form of occurrence, namely in veins. Most, although not all of our economic minerals occur in the form of veins or in forms closely related to them. Veins, although varying widely as to dimensions and inclination, are wall-like bodies that cut the rocks. Most of these veins owe their formation to the action of so-called hydrothermal or aqueous magmatic solutions in the later stages of the igneous process, resulting in mineral deposition in convenient channel-ways in the rocks. There are a great many of these veins scattered through the rocks, but, unfortunately for our optimistic friend and benefactor the prospector, very few of them carry a sufficient concentration of valuable mineral to make them of economic importance. We have now considered very briefly not only the character of minerals, but also the places in which they occur. But you are still muttering to yourselves, "Of what use are these minerals he's been spending so much time discussing?" The answer to this last question brings us very naturally to the main part of my lecture—the economic uses of minerals. It will not be possible in the time remaining to consider this part of the subject in any great detail. I have therefore selected certain striking examples of the practical application of minerals to everyday use. Perhaps you may still find the list too long. If so, you may find some consolation in the fact that your lecturer took a much longer time to collect the data than it will take him to relate the results of his investigation. The useful minerals may for convenience be considered under three headings, namely, ores of metals, gems, ornamental and building stones, and those having uses of a miscellaneous character.

Ores of Metals

Let us consider under this heading only a few of the commoner metals. When we were discussing the general chemical composition of the earth we noticed that aluminium and iron next to silicon are the commonest of all metals. What are the ores of aluminium then? As already mentioned, there are a great many minerals in the earth's crust that have an aluminium content. Generally this light metal is combined with such metals as silicon, magnesium, calcium, iron. sodium, and potassium. On this account most aluminium-bearing minerals are not used as ores of the metal either because the proportion of aluminium is too small or because the difficulty of separating it from the other elements is too great. At the present time, although there are over sixty compounds of aluminium, only two are used for the extraction of this light metal. These are a hydrous oxide of aluminium called bauxite and a sodium-aluminium fluoride called cryolite. These two minerals are smelted together, the cryolite acting as a fluxing material in the electrolytic production of this metal from bauxite, which is the true ore. But since the mineral compounds of aluminium are indispensable to the production of the metal, we may be pardoned for broadening the scope of our discussion of the uses of minerals to include those products made directly from them. To complete this part of the picture we might mention some of the outstanding uses of this metal and its alloys. Housewives are already familiar with its use in the manufacture of modern cooking utensils. Its light weight and its inertness chemically give it a great advantage in this field over other metal materials. Some of the many other uses of this metal and its alloys are in airplane and automobile construction, in transmission lines, for traffic beacons, in television receiving sets. Before turning to the next metal it is interesting to note that an alloy of aluminium, silicon, magnesium and copper, called duralumin, produces a metal that conbines high tensile strength with low weight. This is in common use for airplane construction. You will observe that we do use the commonest metal, silicon, to a limited extent after all. The metal next to aluminium in abundance is iron. Here again there are a great many minerals that include iron in their composition, but again most of them, for substantially the same reasons, are not available as ores of this metal. There are, however, several minerals that may be used as ores of iron. Only two of these will be mentioned in this lecture, since they provide by far the greater proportion of the total amount of this metal extracted from the earth. These are two compounds of the metal with oxygen, or oxides, called hematite and magnetite. The metal iron itself has so many familiar uses that it would be an impertinence to attempt an enumeration of

them. The tremendous scope of its usefulness in the realms of construction and transportation alone has given to this period of man's history the title of the iron age. May I venture instead to point out the wonderful development that has taken place in the use of ferrous material by the inclusion of small quantities of other metals, either in the form of alloys or as minor constituents of certain special steels. One of the most interesting of these is the compound of iron and silicon called ferro-silicon. This is an alloy that has a very important function. It is known as a deoxidizer, i.e. it gets rid of the surplus oxygen in the melt. It is a kind of metal scavenger. Again we see that the commonest metal, silicon, is of some use to us. Other metals that are combined with iron, either as alloys or in the form of special steels are nickel, chromium, manganese, vanadium, titanium, and molybdenum. It is not my intention to mention these in any detail. This is a study by itself. Instead, let me cite one or two striking instances of the application of these alloys or special steels to everyday use. Steel containing nickel and chromium or the so-called chrome plate is used in the construction of automobiles, nickel steel is used for projectiles and bullet envelopes, manganese steel in the construction of railway and street-car switches, while steel containing as much as 36-38 per cent of nickel, on account of its very low coefficient of expansion, is used under the trade name of Invar for blance-wheels of watches and pendulums of clocks. Vanadium and titanium, like silicon, serve as de-oxidizers. We must not forget to mention also the so-called stainless steels, some of which are coated with nickel, while others, as in the case of stellite, contain no iron at all but are mixtures of such metals as cobalt, chromium, and magnesium. If this very short resumé of the iron part of the subject appears to do that important metal less than justice, you will remember that this is owing to lack of time.

The next metal that should engage our attention is nickel. You may be interested to hear the whimsical story of the origin of the name nickel. In the middle ages the Saxon miners were a superstitious lot and they attributed all or most of their troubles in smelting copper ores to the evil influence of certain trolls, gnomes, or sprites of the underworld. Occasionally when treating their copper ores they encountered a pale copper red mineral which was very difficult to smelt by their somewhat crude methods. Since one of the above-mentioned gnomes was called nickel, an early Saxon name for an obstinate person and probably a close relative of Old Nick's, it was natural they should call this mineral kupfernickel or copper with a spell cast over it by the evil spirit nickel. Later it was found that this pale red mineral contained no copper at all, but was an arsenide of another metal with entirely different properties. It was fitting, then, that this new metal should be named nickel after the gnome

of early Saxon days. There are several compounds of nickel to be found in the mineral kingdom. I shall mention to you only the three commonest. These are pentlandite (NiFeS), niccolite (NiAs) and garnierite (an impure hydrous silicate of nickel and magnesium). Of these the first-named, which occurs in such massive deposits in our own Sudbury district, is the most important from the standpoint of world production. A great many uses could be cited for nickel. A few of these are for crucibles, in airplane construction, the three-electrode ionic valve which amplifies small signals a thousandfold, and coinage. The most important of its alloys are those with copper. Nickel and copper appear to combine with each other in all possible proportions. The most important of these, however, are shown in Table I. Nos. 1 and 2 are used for bullet envelopes, No. 3 for coinage, No. 4 for electric resistance material, and No. 5 Monel metal for sinks and other domestic appliances. It is interesting to note that Monel metal is smelted directly from a combined nickel-copper ore of the Sudbury district. Its composition is consequently not always as constant as indicated in the table.

TABLE I

(1)	15%	nickel,	85%	copper
(2)	20%	" ,	80%	"
(3)	25%	" ,	75%	"
(4)	40%	" ,	60%	"
(5)	70%	" ,	30%	"

Before leaving the so-called base metals, may I review hurriedly the common ores of copper, lead, zinc, and tin and mention some at least of the common uses of these metals and their alloys. The common ores of copper are chalcopyrite, chalcocite, and bornite, sulphides of copper, cuprite, an oxide, and copper in the uncombined form called native copper. The metal itself is used for conducting electric current and for coinage, while the useful alloys include brass (Cu and Zn), bronze (Cu and Sn or Cu and Al) and gunmetal (Cu, Sn and Zn). Coming now to lead, the only important ore of this metal is galena, a sulphide. Lead is used for piping and sheeting and in combination with tin as pewter, solder, and Chinese tea lead, and with tin and antimony as type metal. Zinc also has but one common ore mineral, again a sulphide, called sphalerite or zinc blende. The main use of this metal is in the manufacture of the so-called galvanized iron, a thin sheet iron coated with zinc, but it is also used in linings for boxes and for printing-plates. The chief ore of tin is the mineral cassiterite, an oxide. The familiar tin-can provides the chief use of this metal. These containers are composed of thin sheet iron

coated with tin. Collapsible tubes, used for tooth-paste, face lotions, and I know not what other mysterious cosmetics, used in milady's boudoir, and alas, outside of it too, are made of pure tin or of lead plated with tin. And now, to complete this part of our story, we must take up very briefly the so-called noble metals, gold, silver, and platinum.

So we come now to the precious metal that is so prominent in the mining and financial world at the present time—gold. This precious metal has recently become notably enhanced in value by a mysterious process called "going off the gold standard", the intricacies of which are far beyond my capacity to fathom. While it used to be quoted at $20.00, it now brings about $35.00 an ounce. Surely a wonderful stimulus to the gold-mining fraternity and, while extra taxation has taken some of the surplus profits, the only complaints that have arisen are of a kind similar to those of the bridge player who laments the perfectly good cards he is compelled to discard while taking in perfectly good tricks. Gold is not a metal that combines readily with other elements, and it is generally found in the uncombined state as native gold. Our own Porcupine and Kirkland Lake districts afford good illustrations of this type of occurrence, although it does occur in the latter area combined with the rare element tellurium. It is this property of chemical inertness that makes gold so valuable. Unlike silver, which changes very rapidly, as many a housewife can testify, this metal remains unaltered through the years. It is significant that gold is the first commodity definitely mentioned in the Bible after the institution of the Garden of Eden, "And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads; the name of the first is Pison: that is it which compasseth the whole land of Havilah, where there is Gold" (Gen. 2, 10-11). Again the uses of this metal, in the manufacture of coins, of ornaments, and of plate, are familiar to all. Copper, silver, and iron are combined with the precious yellow metal to give golds of different tints for use in the manufacture of jewellery. Table II gives the shade of the alloy and its composition.

TABLE II

Golds

Yellow	—fine gold 24 parts
Red	—gold 18, copper 6 parts
Green	—gold 18, silver 6 parts
Blue	—gold 18, iron 6 parts
White	—gold 12, silver 12 parts.

Small amounts of gold are used in gilding and in producing a golden appearance in such articles as sign-boards, china trays, and book-edges. I think you will agree with me that its beautiful yellow colour and its resistance to change make of this precious metal "a thing of beauty and a joy forever".

In concluding our brief discussion of the noble metals, let me mention the main ores of silver and platinum and the practical application of these metals or their alloys. The most important ores of silver are silver uncombined, native silver, and the silver sulphide called argentite. As you already know, the metal is used in the manufacture of coinage, articles of jewellery, and plate. The so-called Sheffield plate has silver, plated on copper. Let me warn you, therefore, not to let your domestic help scrub it too strenuously or you may get down to the copper. Platinum usually occurs as native platinum, although the metal does occur in our Sudbury deposits combined with arsenic as the mineral sperrylite. The name platinum is derived from a Spanish source and has reference to its resemblance to silver or "plata", "platina" being the diminutive form. This metal and the related metals of the same group possess a remarkable set of properties that render them extremely valuable in the realm of scientific research and in industrial processes. These are chemical inertness, high melting-points, low electrical conductivity, and low coefficient of expansion. Platinum is used chiefly in the chemical, electrical, dental, and jewellery industries. In chemistry it is valuable as chemically inert containers, or as catalysts, agents that facilitate chemical reaction without taking part in it. In the other fields it is used for electrodes, for dental bridge-work, and as a matrix for porcelain inlays and as settings for diamonds. After this very brief discussion of the metals and their uses, we shall now pass on to a brief consideration of the minerals used as gems, ornamental stones, and building stones.

Gems, Ornamental, and Building Stones

This part of our subject may conveniently be taken up under the three headings already mentioned. The first of these three always finds favour in the eyes of the ladies, as some husbands know to their cost. It is but fitting, therefore, that we should start with them. Before describing those minerals used for this purpose, let us see what properties in minerals make them valuable as precious or semi-precious stones, as ornamental stones, or as building material. Since in considering building material we are concerned primarily with rocks with characteristic structures of their own, it will be best to consider the minerals of the first two sub-divisions by themselves and afterwards to discuss those rocks used

for building stones. There are in general four properties that are important in a consideration of precious and semi-precious stones. These are hardness, colour, lustre and transparency. With very few exceptions all gem-stones must be resistant to abrasion, otherwise they will not endure. In the case of some gems, such as ruby and sapphire, depth of colour is the other important factor in a consideration of value, while in others, such as the diamond, lustre plays the leading role. Most gem-stones are either transparent or translucent; very few of them are opaque. But you say, "What do you mean in this connection by the terms transparent, translucent and opaque?" Well, I always illustrate this to my classes by telling a story. My students have had to listen to it each year for many years, but fortunately, for the most part, not the same individuals. A student was writing an examination in mineralogy in a room where the windows were exceedingly dirty. One question on the paper asked for the meaning of the terms transparent, translucent, and opaque. His reply was: "The windows in this room were formerly transparent; they are now translucent, and if they are not washed very soon they will become opaque." As the names imply the chief difference between precious and semi-precious stones lies in the value and there is, of course, no fixed line of division between them. Certain stones are precious because of their rare occurrence, their unusually deep colour, their striking lustre, while others being more common, possessed of a lighter colour, and with less pronounced lustre, are classed as semi-precious. Then, too, fashions in gems change just as do fashions in feminine apparel, and with just as little apparent cause. What is precious to-day may be semi-precious to-morrow. It is not possible to take up all the gems in this lecture. In any case this field has already been covered by my colleague, Professor Parsons, in one of the Royal Ontario Museum lectures. It will be sufficient to mention but a few of the more important of them. We start, quite naturally, with the diamond.

Diamond—This is a mineral, as you all know, that is made up of the single element carbon. Its very brilliant lustre, its fire, and its transparency are the properties that place it in the precious stone class. It occurs in two different types of deposit, namely, in place in an igneous rock called peridotite, and in the so-called placer deposits in sands and gravels. These placers are interesting fragmental deposits that result from the mechanical and chemical breakdown of rocks and veins and their subsequent transportation by water action to river terraces, which may later be left above water-level by changes in elevation. The main material of these terraces is, of course, sand and gravel, but on occasion such minerals as gold, platinum, cassiterite, diamond, ruby, and sapphire may also be included. The Kimberley and Pretoria districts in South Africa

have long been famous for their production of diamonds. The gems occur in both forms in these fields, but the placer deposits are now pretty well exhausted. As the lustre of the diamond is its most valuable property, it is cut in such a way that the maximum amount of light will be collected and reflected both from the many facets of its setting and from the interior of the stone. This light is refracted into its component colours, giving rise to the fire of this beautiful stone. At the present time the supply of diamonds exceeds the demand and it is only by a rigorous control of output that the high price is maintained. In this connection it is related that one inidvidual had such a "nose" for diamonds that he was paid a substantial salary *not* to find them.

Ruby and Sapphire—These gems are unusual varieties of the fairly common mineral corundum, which is a compound of aluminium and oxygen. The transparency and the beautiful red and blue colours are the important properties of these gem-stones. They are also made synthetically and it is interesting to note that, as pure aluminium oxide is colourless, foreign materials are introduced to imitate the rich reds and blues of the natural stones. The most famous locality for ruby is Burma, where it occurs both in a crystalline limestone and in placer deposits, while sapphire is found in Siam and Ceylon in the same forms as is the ruby in Burma. As the lustre of these stones is rather poor and the colour on the other hand so rich, the settings for these stones are usually of the deep or step-type with few facets. On account of their rarity, large pigeon's blood rubies are from eight to ten times as valuable as diamonds of a corresponding size. Large sapphires, on the other hand, are much commoner and are about equal in value to diamonds of the same size. Both these stones however have always been classed as precious stones.

Beryl—Beryl is another mineral that provides three important gems for our consideration. Its composition is that of a silicate of aluminium and the rare element berylium. The three varieties are emerald, a precious stone, and aqua-marine and golden beryl, semi-precious stones.

Semi-precious Stones

There are many other minerals, varieties of which are used for semi-precious stones. Most of these are listed in Table III.

TABLE III

List of Semi-precious Stones

1. chrysoberyl
2. feldspars
3. garnet
4. jadeite
5. lapis-lazuli
6. nephrite
7. olivine
8. opal
9. quartz
10. spinel
11. spodumene
12. topaz
13. tourmaline
14. turquoise
15. zircon

The minerals in this table are for the most part gem material whose value depends largely upon its colour. Exceptions to this general rule are provided by the colourless varieties of quartz, topaz and zircon, where transparency and lustre are important factors, and by such iridescent stones as opal, chrysoberyl, and the varieties of feldspar called moonstone, labradorite, and peristerite. Of the different colours represented, reds and pinks are illustrated by garnet, quartz, spinel, and tourmaline, browns and yellow by zircon, garnet, quartz, topaz, and tourmaline, greens by chrysoberyl, garnet, jadeite, nephrite, olivine, quartz, tourmaline, and the green feldspar amazonite, blues by lapis-lazuli, topaz, tourmaline, and turquoise, and violets by garnet, spodumene, and the purple variety of quartz called amethyst.

Ornamental Stones

We turn next to a brief consideration of the ornamental stones. Colour is the important property here. As in the case of the gems, the value of an ornamental stone varies with fluctuations in fashion. These stones are generally used either as features of interior decoration, such as pillars, base-boards, or mantels, or in the manufacture of mosaics and ornaments. The stones that I should like to cite in this connection are given in Table IV.

TABLE IV

List of Ornamental Stones

1. azurite
2. chrysocolla
3. cinnabar
4. garnierite
5. hematite
6. jasper
7. labradorite
8. malachite
9. pyrite
10. rhodonite
11. serpentine
12. smithsonite
13. sodalite

Of the minerals listed in the above table azurite, smithsonite, and sodalite are blue, chrysocolla is a blue-green, garnierite, malachite, and serpentine are green, cinnabar, hematite, and jasper are red, rhodonite is pink, pyrite is a metallic yellow, while labradorite has already been mentioned under semi-precious stones.

Building Stones

The rocks that are used for building purposes are probably better known to you than any of the minerals used as gems or as ornamental stones. Since we are dealing here with rocks, made up usually, though not always, of aggregations of two or more minerals, we must look to their petrographic, rather than their mineralogical peculiarities in a consideration of what makes them valuable as building material. Briefly stated, the sedimentary types are easy to quarry and cut, but are less durable, while the coarse-grained igneous types used are hard to manipulate but are very durable. The metamorphic rocks owe their economic importance to the two concomitants of metamorphism, namely, the parallel arrangement and the re-crystallization. The following are some of the common types of building stone and their application: granite, syenite, serpentine, sandstone, limestone, gneiss, slate, marble. Of these types granites and syenites are used chiefly for facing, trim, and monumental stones, serpentine for base-boards of store-fronts, sandstone and limestone for general building purposes, gneiss for fireplaces and mantels, slate for roofing material, and marble for interior decoration. There is another sediment that is used indirectly in the manufacture of a large proportion of our construction material. This is clay or the hardened rock representative shale, both of which consist chiefly of the mineral kaolin, which is made into bricks. We see so much of this material every day that it has become a commonplace. Perhaps, however, this reminder of its origin will not be amiss. It may be mentioned in passing that the dividing-lines between the different divisions of gem, ornamental, and building-stones is not well marked, and they grade insensibly from one to another. We may now turn our attention to

Other Useful Minerals

This division should include all other uses not yet touched upon, but limitations of time and patience again lay a constraining hand on the lecturer, forcing him to confine himself to a few examples. We may subdivide this division once more into four heads—those minerals used (1) as abrasives, (2) as pigments, (3) as refractories, (4) for miscellaneous purposes.

Abrasives—Minerals to be useful for this purpose must have a high hardness. Practically no minerals with a hardness less than that of ordinary steel can be utilized. There are quite a number in this range of hardness, but comparatively few of them are used. For the purposes of this talk it will be sufficient to cite the four minerals, diamond, corundum, garnet, and quartz. Diamond dust is used in cutting and polishing gem-stones of all kinds, including diamonds themselves, while the inferior, flawed stones or black diamonds are used extensively in rock-drilling. By means of the rock drill, in which these inferior diamonds are set, thousands of feet of underground exploration are revealed in the form of small cores about 1″ in diameter. This type of exploration makes available knowledge as to petrographic succession and limits of ore deposition. Common corundum and an impure ferruginous variety called emery are used in the manufacture of abrasive wheels and powders, while garnet and sand or quartz papers are common abrasive agents. In addition quartz is used in the form of abrasive wheels and as the agent in the sand-blast for cleaning stone buildings.

Pigments—Approximately 60 per cent of the commercial colouring materials and artists' paints are of mineral origin. In the commercial field whites of different degrees of durability are provided by compounds of Ti, Ba, Zn, Pb, Mg, and Sb, yellows by compounds of Pb, Fe, and Cd, greens by compounds of Cr, most of the browns, a few of the blues, and some of the reds by compounds of Fe. These colouring compounds, frequently oxides, are all derived from minerals. On the other hand, most of the blues and purples and some of the reds are of organic origin. Another interesting colouring material is the so-called aluminium paint, a finely-divided suspension of the metal itself, which, on account of its high reflecting power, is used as a coating of moving-picture screens, bridges, and street signs. On the artist's palette we find that cobalt compounds supply blues, violets and greens, chromium compounds yellows and greens, mercury compounds vermillions and greens, cadmium compounds maroons and yellows, and iron compounds reds, yellows and browns. It is obvious that all of these also are of mineral origin. A beautiful blue called ultramarine, which is highly prized by artists, was formerly made by grinding up the semi-precious stone lapis-lazuli. It is now made synthetically.

Refractories—The minerals coming in this category have high melting points and consequently find an extensive use where high temperatures are anticipated. Chief amongst these refractories is mineral wool, or asbestos. There are two kinds of mineral wool which are extremely fibrous varieties of two different minerals. One of these is a fibrous variety of amphibole and is spelled with a u, while the other is a fibrous

variety of serpentine and is spelled with an o. These are silicates whose complex composition will not be added to your other troubles. Both of them are in such finely fibrous form that they may be woven into fabrics of different sorts. They find an extensive use as insulating or non-ducting material of all kinds and in the manufacture of fire-proof roofing-slates. Other minerals used in this direction are graphite, muscovite, and talc. The older members of the audience will remember the mica fire-doors in the old-fashioned base-burners. The mica used was muscovite. Nowadays it finds a much wider application as insulating material for electrical apparatus. Graphite is invaluable for the construction of crucibles which will stand the intense heat of the assay furnace, while talc or soapstone is familiar at least to the feminine portion of this audience as the chief material of the so-called fireless cooker.

Miscellaneous—We could profitably spend more than the usual lecture period in a discussion of miscellaneous uses of minerals. Let me hasten to assure you, however, that I shall limit myself to a brief discussion of but a few. No lecture dealing with the uses of minerals would be complete without some mention of those minerals used in making glass, porcelain, and china. In the construction of glass, quartz has always been the most important mineral used. This is still the case, but the potash feldspar, orthoclase has recently been added to impart a tougher quality to the product. The so-called unshatterable glass used for automobile wind-shields and windows owes its toughness in part at least to the admixture of this feldspar. In the manufacture of porcelain and china the materials kaolin and orthoclase are in common use, the former rather more than the latter. Another mineral that surely deserves mention as one of the most useful we have is gypsum ($CaSO_4.2H_2O$). This is a mineral with many uses. It will be sufficient to cite but three of them, namely, in the manufacture of fertilizer, plaster, and building-material. Many rocks are used in the construction of roads and sidewalks. In concluding this part of the talk, attention must be called to a few more striking examples of the role played by minerals in our everyday life. First there is the use of talc as a toilet-powder, second there is halite or rock-salt, a condiment in use on every man's table, third there is the use of such minerals as galena as detectors on crystal radio-sets, fourth there is the graphite used in all lead-pencils. The next mineral or group of minerals requires a little preliminary explanation. This group of minerals, called the zeolite group, has the general composition of silicates of Al, Na, and Ca, with water. Some contain more Na, some more Ca than others. They interchange the one for the other very rapidly. This latter property is made use of in the softening of water. All naturally

occurring water contains salts of both Na and Ca. If Na predominates over the Ca, the water is said to be soft, while when the reverse is the case, it is said to be hard. Hard water passed through zeolites rich in Na gives up its Ca in exchange for the Na provided by the zeolite, making the water soft.

There may be cited next the use of mineral products as insecticides. Prominent in this connection are compounds of Cu, Pb, As, Ca, and S. Paris green, which is a compound of Cu and As of mineral origin, is in common use as a demoralizer of the familiar potato bug. Finally, many of the pharmaceutical products used in modern medicine originate with the minerals. Time does not permit the enumeration of all of these, but various compounds of bismuth and mercury furnish striking examples. The gory appearance of the knees and elbows of the rising generation is largely due to injuries complicated by the ubiquitous mercurochrome. The old-fashioned remedy of molasses and sulphur, which has lost favour in modern medical circles, is partly at least of mineral origin.

And now, having given the minerals what must have seemed to you a long, but was really a very brief, review, and having inquired into some at least of their uses, I hope I have persuaded you that they really do surround us wherever we go. This, ladies and gentlemen, is my complete story for the evening. I conclude with another quotation from the same minor poet.

And now I hope that all this dope
You have been given in the lecture
Will help reveal their taste and feel
And also something of their texture.

But most of all in this big hall
I hope there has been demonstrated
How every day, in every way,
To every use they're consecrated.

If this is so, as home you go
Just look about you at your leisure,
Ah, then you'll find, with open mind,
That Mother Earth has hidden treasure.

THE REALM OF THE HONEYBEE

JAS. I. HAMBLETON

Although the honeybee is in itself a small creature compared with many other forms of animal life, its realm nevertheless extends into practically all civilized countries of the world and, in fact, well beyond. Man and honeybees have been associated for centuries, but the honeybee has not become domesticated in the strict sense of the word, certainly not domesticated as have other common types of livestock. Honeybees can maintain themselves for generation after generation in most regions that support an abundant nectar-secreting flora.

Owing to the widespread distribution of the honeybee, honey is known the world over and, while not a major article of commerce, it is one of the most widely known of man's foods. Even wheat and milk are more restricted in distribution.

The limiting factor in the world-wide occurrence of this valuable insect seems to be honey flora. Climate, which ordinarily restricts the habitat of many animals, is of secondary importance. In the United States, for example, apiaries are to be found in the high mountainous altitudes; the wind-swept plains are dotted with thousands of white hives; flowers attractive to honeybees grow luxuriantly in our deserts; the swamp areas of the Southern States teem with this insect; and honey production in the Imperial Valley of California, some 200 feet below sea level, is an important industry. Beehives may be found in almost every corner of the United States, there being approximately 4½ million colonies scattered throughout the length and breadth of the country; and in the aggregate these produce between 150 and 200 million pounds of honey annually, not to mention 5 to 8 million pounds of beeswax.

Weather factors play an important rôle in the husbandry of the bee, although, as stated, climate as a factor influencing its distribution is more or less inconsequential. Colonies whose ancestors have always lived in the Tropics, when transplanted to the Far North, immediately make themselves at home, so to speak, requiring no time to become acclimatized; and, given a good start, they can do this without the help of man and even make preparations to withstand a long, cold winter, a season of which they have had no experience. Live honeybees are constantly being transported from one part of the world to another, and every land has experts who specialize in the production of queens,

for which there is a ready market. Both fanciers, of which there is no lack in the beekeeping brotherhood, and commercial honey producers are ready customers of the professional queen-breeders.

North America has no native honeybee. The first bees were brought here by the Spanish settlers, and conditions were so propitious that honeybees were soon found in all parts of the country. The American Indians, to whom the honeybee was as strange as the white man, called it the "white man's fly."

Various races of honeybees have been imported into Canada and the United States, the most important among them being Italians, Caucasians, Carniolans, and Cyprians. Comparatively pure strains of these can be found, but all the races have interbred so that there is no end of hybrids and intergradations.

Irrespective of the countless ages of close association between man and the honeybee, there is no evidence that man has changed it, with the possible exception that certain distinct yellow strains have been developed. We are therefore dealing with a truly wild animal which has held itself aloof and maintained itself since before the coming of civilized man. Reference is often made to domesticated bees as being distinct from wild bees. This is a fallacy; at least, it has no morphological or taxonomic basis. Honeybees whose ancestors have been confined to life in hollow trees and caves can be placed in a modern hive and made to produce honey just as easily as colonies that in their early past have known only the best of man's care.

Another fallacy requires attention, namely, that bees know their master and will not sting him. How absurd that an insect that lives only six weeks, is handicapped by deafness, and stays at home very little during the daytime should become intimate with its keeper! Bees are creatures of instinct and fixed habits. The observant keeper learns their habits and so with seemingly magical power can work among them in comparative safety. He enjoys the halo of immunity with which his friends have surrounded him, but accepts it as a tribute to his skill. It is true that every beekeeper gets his quota of stings, but he looks upon the bees' stinging habit as an asset rather than a detriment. He understands that his pets are only following a blind instinct to protect the colony, and that when he works among them with calmness and assuredness—and this takes a certain amount of courage, it is true—there is little for him to fear.

Many rather plainly evident facts are known about the honeybee family. But what guides the colony, what enables it to perform all its varied and exacting tasks, and why does it accomplish its ultimate purpose in such a perfect and harmonious manner? Such mysteries

have not been solved. The guiding spirit, whatever it is, is as intangible as the soul in man. True, the colony is headed by a queen; but she bears an empty title, as there is no evidence that the queen in any manner guides the destinies of her large family.

The queen is the only perfectly developed or true female in the colony, the only bee that has the function of reproduction, aside from the essential part played by the drones or male bees, of which there may be several hundred to a few thousand in a colony. The majority of the colony is made up of worker bees, imperfectly developed females, which possess all other maternal instincts save that of reproduction. The workers are well equipped with wax-secreting glands and glands that secrete royal jelly and larval food. They also have a well-developed honey stomach, and a sharp sting never used in self protection but as a mortal sacrifice in defense of the colony. On the other hand, the drone has no wax glands and has only a small, shrivelled honey stomach, and he makes no attempt to gather nectar or pollen. His only apparent reason for existence is to mate with a virgin queen, and the individual, perhaps only one in ten thousand, who is destined to play this part sacrifices his life in doing so. Thus no queen, worker, or drone ever has a living father.

The mysteries of these creatures deepen as we delve into their life history. The mated queen, for instance, carries the male germ cells in her body the rest of her life, and with these she is able to regulate the sex of her offspring. She thus can lay either fertilized or unfertilized eggs. The former develop into either workers or queens, while the latter develop into drones. Since the egg from which the drone is derived is not fertilized, it is quite evident that the drone has no father; but since fertilization is required to produce a queen, a queen must have both a mother and a father. Thus we are confronted with the strange anomaly that male bees, although always fatherless themselves, nevertheless have grandfathers!

The complex and perfect organization of this communal group is further evident from the astonishing manner in which the diet of the young is utilized in the development of the two castes, workers and queens. Both arise from a fertilized egg, yet the morphological differences between them are extreme. In contrast to the worker bee, the queen has no wax glands, a small honey stomach, and no pollen baskets. Although much larger than the worker bee, she develops to maturity in 16 days, whereas the worker bee requires 21 days. The worker bee has a straight, barbed sting, which it loses once it has inserted it into the flesh of an enemy. The queen, on the other hand, has a curved, smooth sting, which can be used with impunity. All these pronounced differences are the result merely of a change in the diet while the bee

is still a blind, helpless larva. The worker larva is fed royal jelly for three days. The larva from which a queen is to be developed is continued on this diet for two days longer, and it is these two days of special feeding that largely makes her a so-called royal personage instead of an ordinary worker.

The hum of bees in a clover meadow and their visitations to our flower gardens are well known to all of us. We also suspect that their indefatigible labour is not unproductive, but that they are returning home laden with patiently gathered nectar, which some day will reach our tables in the form of rich, mellow honey having a bouquet that bespeaks its source. By payments in honey and beeswax these creatures well compensate man for his care, for they produce an annual harvest in the United States and Canada of more than 100,000 tons of honey and perhaps somewhere between 7,000,000 and 12,000,000 pounds of beeswax.

Far outweighing this in importance is a less known and less measurable gratuity that honeybees bestow upon mankind. In its search for nectar and pollen, the honeybee inadvertently fertilizes the blossoms. This has been likened to a marriage ceremony in which the bees act as priests to the flowers. Without this visitation many plants, both wild and cultivated, would be barren and yield no fruit. It would indeed be a less livable world without apples, pears, plums, cherries, and many other fruits. And how many of us, in the midst of enjoying the incomparable lusciousness of a well-flavoured cantaloupe, ever give thanks to the honeybee for the part it played in the development of such fruit? For without the visits of insects to plants that require cross pollination, all the labour of cultivation and protection from pests would be lost. And of all the insects upon which man now depends to fertilize many of his fruit, vegetable, and forage crops, the honeybee is by far the most important and the most dependable, and is the only insect that man can employ to perform the intricate and infinite task of cross pollination.

The keeper of bees, whether a large commercial producer or an amateur, is a benefactor to mankind. He has a place in every community, and his interest in bees should be encouraged to the utmost, because as the bees fare so fares the world and should a catastrophe befall the honeybee, which is already beset with numerous enemies, a far greater catastrophe would befall mankind.

SURVEYING THE OUTER UNIVERSE

HARLOW C. SHAPLEY

Dr. Shapley pointed out that while astronomy had some claim to being the oldest of the sciences, it was still forging ahead into new fields, and cited as new discoveries of the last year or so, a new star, the demonstration of a magnetic field around the sun, the demonstration of the essential correctness of the theory of relativity, the deduction of a new value for the rate of expansion of the universe, the disproof of the long-time scale for the age of the universe and the further exploration of the outer universe.

Dealing specifically with the continued exploration of the outer universe, Dr. Shapley dwelt on the technique of such investigations as they are carried out by the Harvard Observatory and its co-operating observation stations scattered throughout the world.

By abundant slides, the essentials of a galaxy were first presented and then the different types of galaxies were described. How astronomers determined what they have been able to find out about the dimensions, distances, physical properties, etc., of these was then discussed and the significance of the findings elaborated.

Dr. Shapley pointed out finally the magnitude of the undertaking and declared that at the end of another ten years the survey of space for a hundred million light years should be virtually complete.

HOT SPRINGS OF YELLOWSTONE PARK

ARTHUR L. DAY

Two types of springs are found in the hotspring area, a shallow acid type without outlet, and the intermittent alkaline geyser kind. Yellowstone Park is a ryolite plateau approximately 10,000 feet above sea level underlain by magma from two distinct volcanoes, which is still in the process of solidifying and is hence giving off gases. Of these, about 98 per cent. is superheated steam, and among the remainder is hydrogen sulphide which becomes oxidized to sulphuric acid, the action of which renders the ryolite very porous and easily penetrated by the surface water which is so abundant in this region of heavy rainfall.

It is estimated that of the water discharged by the Yellowstone geysers, about 95 per cent. is surface water and not more than 5 per cent. from the magma. The action of these geysers is well illustrated by that of the "Giant" which, while active, discharges a stream 7 x 5 x 125 feet for an hour, with intervals of approximately 65 minutes. The crater of this geyser is approximately 7 x 5 x 21 feet with a channel entering from the side near the bottom.

After ten years of study, Dr. Day and his colleagues have concluded that this external crater is connected by a continuous underground channel to several reservoirs whose walls have become steam-proof through chemical action. The heating is done by superheated gases from the magma, but the exact mechanism which finally sets the geyser in action is not understood. Following his discussion, Dr. Day took his audience through the hotsprings region of the Park by a series of beautifully coloured lantern slides and two reels of unique motion pictures.

BOTANIC GARDENS FOR CANADA

H. T. Güssow

The lecturer emphasized that the general public of Canada had, so far, not appreciated the cultural and utilitarian aspects of Botanic Gardens. The general impression prevails that a Botanic Garden serves primarily as a sort of amusement park, or a park anyway with public drives through it and beautiful flower beds and attractive floral displays generally. While, of course, such gardens should serve by their displays as an attraction to the general public, this is by no means their principal purpose.

Owing to the fact that Canada has no such institution of its own, people are not familiar with the real purposes for which almost every country of the Empire maintains such gardens. We have in Canada numerous art galleries, museums and similar purely educational and cultural institutions, the existence of which is not challenged and many of which are enjoying the patronage of the people of Canada. Their utilitarian value is largely educational and cultural. A proper botanical garden, such as the lecturer drew a vivid picture of, at least one Canadian National Botanic Garden, is urgently required in order to serve the interests and industries dependent upon our own and the world's general vegetal resources.

The lecturer quoted Sir Joseph Chamberlain in a glowing tribute paid to the Royal Botanic Gardens, Kew, in the British House of Commons in 1898 when he said: "I do not think it too much to say that at the present time there are several of our important colonies which owe whatever prosperity they possess to the knowledge and experience of, and assistance given by the authorities at Kew Gardens." This warm appreciation of the tremendously valuable services rendered to many parts of the Empire reflect clearly the utilitarian purposes and duties of such an establishment, and were it but realized by the general public, that an organization of the type contemplated for Canada by the lecturer is not only a thing of beauty, but actually is in a position to perform services which are unlimited and which certainly will make for prosperity in many directions, they surely would strongly support the endeavours made by wide awake larger cities and all of our universities to have such institutions provided without further delay. Indeed the lack of development has been emphasized by Sir Arthur W. Hill, Director of the Empire's

most famous Garden—Kew—in an account of his visit to Canada in 1927: "Canada does not appear to have realized the importance of Botanic Gardens, not only for their educational value for the proper display of the great wealth of the vegetable resources of the Dominion, but also as centres where researches in the sphere of genetics and in the introduction and improvement of economic plants can be prosecuted. The formation of one or more Dominion Gardens is one of the most pressing needs and all the more urgent in order that land suitable for the purpose may be secured before it can be irretrievably seized by the ever spreading march of building operations."

There is hardly a more suitable organization possible than an up to date Canadian Botanic Garden to make, in the first place, the resources of Canada, economic as well as aesthetic, better known both at home and abroad. Most of these gardens are great centres of attraction and Kew Gardens are being enjoyed by far over a million visitors every year. Naturally, people fond of beautiful grounds consider such a garden as a most pleasant retreat for occasional restful hours, where there is no traffic, no noise of streets and highways, but where one may feel in harmony with nature.

The lecturer then described briefly some of the outstanding achievements of famous botanic gardens—the discovery of the quinine bark, the rubber trees, the vast number of medicinal and economic plants in use by mankind, etc. Indeed, he concluded, the services which the science of botany has already rendered to mankind and is still liable to render once these pursuits are put on a basis more commensurate with an important country as Canada, will generously compensate for the expenditure in getting such a garden under way. It is of interest to record here a statement in the report made by a commission appointed in 1838 to report on the future management and working of the (then) Royal Household Gardens. "Everything should be systematically arranged and named; there should be distinct departments both in the open air and in houses for medicinal, economical and agricultural plants, nurseries for the propagation of plants for Government exportation or for public purposes." "It is inconceivable," it adds, "that Parliament would refuse the money for this purpose if the Garden were really remodelled with a view to such objects as those described." One could, without fear of committing an error, adopt the policy of almost a hundred years ago and apply it to the establishment of Canada's first National Botanic Garden.

The lecturer congratulated the Toronto committee on Botanic Gardens for Toronto and expressed the hope that the splendid efforts made by this committee may soon bring about the establishment of

such a garden for Toronto, under the direction of or in the closest association, with the Department of Botany of the University.

Towards the close of the lecture some 75 hand-coloured slides of Botanic Gardens of the Empire were used to illustrate what had been said about the attractiveness of such institutions.

PHYSICAL SCIENCE IN THE PRACTICE OF MEDICINE

RAYMOND C. DEARLE

Dr. Dearle outlined the significance of the interplay of different sciences in those border-line areas that lie midway between our present highly specialized groupings of the natural sciences. When the physicist looks at the human body, he sees in it an energy consuming machine, exemplifying essentially the principles of thermodynamics, supported by a skeletal frame work that embodies engineering statics, motile through a muscular system that operates under physical laws of statics and dynamics, with a circulatory system that introduces all the principles of hydrodynamics, a respiratory system that introduces the physics of gaseous interchange, and a nervous system which recent researches had shown to be operated as an elaborate electrical network.

Such being the case it was obvious that physics should contribute largely and effectively to medical research and the practice of medicine. With a large number of carefully selected examples, which included ergometers, thermo-couples, microcolorimeters, electro-cardiographs, recording stethoscopes, stethophones, audiometers, ultraviolet, X and gamma rays, he showed how physical principles and intruments served directly or were adapted to the needs of medical practice in its experimental, diagnostic or therapeutic phases.

THE DYNAMITE OF DUST

David J. Price

U.S. Research on Industrial Plant Dust Explosions

The Chemical Engineering Division of the Bureau of Chemistry and Soils, United States Department of Agriculture, is engaged in research studies to determine the causes of dust explosions in industrial plants and in the development of methods for their control and prevention. In this research work the Bureau of Chemistry and Soils co-operates with the industries directly concerned, fire prevention associations, safety and insurance organizations, State and Federal boards and commissions and other interested agencies. Among the national organizations co-operating in this dust explosion prevention work are the National Fire Protection Association, National Safety Council, American Standards Association, National Board of Fire Underwriters, National Fire Waste Council and a number of other national organizations in the fire and explosion prevention field. The direct contact with these organizations affords a ready means for translating the results of technical research into practical application.

The attention of the Federal Government was directed to the subject of dust explosions in American industries by an explosion in a cattle feed grinding plant in Buffalo, New York, in 1913. Thirty-three men lost their lives, 78 others were injured and the property losses amounted to approximately $500,000.

Among the more important explosions of this character in Canada the following should be mentioned:

Peterborough, Ont.:	Dec. 11, 1916—Feed and cereal mill: 17 killed, 16 injured, $2,000,000 damage.
Port Colborne, Ont.:	Aug. 9, 1919—Grain elevator: 10 killed, 10 injured, $1,500,000 damage.
Montreal, Que.:	Dec. 1, 1934—Grain elevator: 2 killed, 7 injured, $50,000 damage.

Explosions of less violent proportions have occurred in many other industrial plants in Ontario, Quebec, Nova Scotia, Manitoba, British Columbia and Saskatchewan.

Some Early Dust Explosions in European Countries

One of the earliest dust explosions on record occurred in a flour warehouse in Turin, Italy, on December 14, 1785.[1] This explosion, as reported by Count Morozzo in the Memoirs of the Academy of Science, Turin, apparently originated from the ignition of flour dust by an open light used by a baker's boy while stirring flour.

A dust explosion in the Stettin Flour Mills in Germany in 1858 was discussed in the session of the Polytechnic Society in Berlin on December 22 of that year. Engler reports an explosion of soot dust in the Black Forest in 1885.[2]

An explosion in the Tradeston Flour Mills, near Glasgow, Scotland, on July 9, 1872, resulted in the death of eighteen persons, injuries to sixteen others and property damage of about $350,000.[3]

Early Dust Explosions in the United States

One of the earliest dust explosions reported in the United States occurred in a flour mill at Mascoutah, Illinois, in 1864.[4] The explosion was caused by the ignition of "middlings dust" by an open flame oil lamp.

General interest among the flour milling industries in the United States was not awakened, however, until the explosion in the Washburn Flour Mills in Minneapolis, Minn., on May 2, 1878. This explosion resulted in the death of eighteen men, injuries to several others and extensive property damage.

Some of the earliest work in the United States on explosibility of dusts was carried on by L. W. Peck, instructor of physics, and Stephen F. Peckham, professor of chemistry, both of the University of Minnesota, after the explosion in the Washburn Mills in Minneapolis.[5]

This experimental work done by Peck and Peckham in connection with the coroner's inquest, has been of very great value to investigators of this problem in recent years. In a lecture delivered June 1, 1878, at the request of the millers of Minneapolis, Professor Peck demonstrated by a few simple experiments that under proper conditions practically

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[1]American Miller, Chicago, 1889. A Flour Dust Explosion a Century Ago, Vol. 17, p. 20.

[2]Beyersdorfer, P., Staubexplosionen—1925.

[3]Jour. Soc. Chem. Ind., Jan. 31, 1906, Vol. 25, No. 2, p. 54.

[4]Dust Explosions, Price and Brown, Nat. Fire Prot. Assn., Boston, 1922.

[5]Mines and Minerals, Sept. 1908, p. 55, Chemical Engineering, March-April-May, 1908.

all combustible material, when finely divided, forming a dust or powder, would burn with explosive rapidity.[6]

To enable the coroner's jury to appreciate the violence of the Minneapolis explosion, Peckham informed the jurymen that from a sack of flour weighing 98 pounds and evenly distributed in a room containing 4,000 cubic feet of air, enough force could be generated to throw a weight of 2500 tons 100 feet high.[7]

Explosions in Grain Threshing Machines

The U.S. Department of Agriculture has given attention to the prevention of dust explosions in grain threshing machines, particularly in the Pacific Northwest. In one threshing season there were approximately 300 of these explosions and fires in the wheat-growing sections of eastern Washington, northern Idaho and northeastern Oregon, causing a loss of about $1,000,000.[8]

In another season, 166 cases were studied in detail by Department of Agriculture investigators and effective control and prevention methods were developed.[9]

Theory and Nature of Dust Explosions

From the research work on this problem, it is now generally accepted that in theory a dust explosion is somewhat similar to a gas explosion. The dusts require definite ignition temperatures and also have what may be termed the lower and upper limits of concentration for explosion. For example, methane gas (mine gas), CH_4, to be explosive, requires a mixture of 5.5 per cent. gas and 94.5 per cent. air, which we term the lower explosive limit. When the mixture contains approximately 10 per cent. of this gas and 90 per cent. of air, the explosion is most violent. When the gas is increased to about 15 per cent. with 85 per cent. of air, the mixture becomes non-explosive and cannot be ignited. This is termed the higher limit of explosive concentration. These limits of concentration vary with different dusts as well as with different gases.

The ignition sources of explosive dusts are practically identical with

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[6]Peck, L. W., Popular Science Monthly, Vol. 14, p. 159, 1878.

[7]Folwell, History of Minnesota, 1926, p. 134.

[8]State College of Washington Bulletin 117, Report of fires occurring in Eastern Washington during the summer of 1914.

[9]U.S. Department of Agriculture Bulletin 379, "Dust Explosions and Fires in Grain Threshing Machines," by D. J. Price and E. B. McCormick.

those of explosive gases so that any source which will ignite explosive gases will ignite explosive dust clouds. These sources of ignition include matches, open flames, electric sparks and fires.

One of the principal factors in the explosibility of dust appears to be the degree of fineness of the dust. The explosion appears to result from the propagation of flame through a finely and uniformly divided dust cloud. This flame travels at a rapid speed, building up considerable pressure and thereby producing what we ordinarily call the explosion. It has therefore been extremely difficult in certain instances to determine definitely when the fire ended and the explosion started. It would appear that any fire might result in an explosion if combustible dust clouds are present.

The ignition of an explosive mixture of dust and air results in a primary flash or explosion of limited proportions. The concussion accompanying this primary ignition, however, is sufficient to shake into suspension the dust that has settled, lodged, or accumulated on ledges, beams, girders, machinery parts, and inaccessible points in the plant. The dust forced into suspension in the air in this manner feeds the flame or fire from the first or primary explosion and causes a secondary explosion of larger proportions in which higher pressures are developed and considerable violence results.

The importance of removing the settled or "static" dust in an industrial plant is therefore a vital factor in dust explosion control and prevention. If there is not sufficient dust to permit the primary flash to propagate, the flame gradually dies down, and there is no secondary explosion.

Economic Importance of Dust Explosion Prevention

For some time it was generally assumed that dust explosions were confined almost entirely to grain-handling and grain-milling plants. The investigations of the Bureau of Chemistry and Soils show, however, that under favourable conditions a dust explosion can occur in any industrial plant or manufacturing establishment where combustible dust is created during operating processes.

A recent survey has shown that the dust explosion hazard exists in a wide range of industries, such as flour and feed mills, grain elevators (both terminal and country), starch factories, sugar refineries, woodworking plants, powdered milk plants, soap powder factories, sulphur crushing and pulverizing plants, hard rubber recovery plants, cork pulverizing plants, chocolate and cocoa plants, paper mills, insecticide plants,

celluloid and textile plants, aluminum, zinc and magnesium plants, fertilizer plants and rosin handling plants.

Approximately 28,000 industrial plants in the United States are subject to the dust explosion hazard. These plants normally employ approximately 1,325,000 persons and manufacture products having an annual value of more than ten billions of dollars ($10,000,000,000).

In the work on dust explosions and resulting fires in industrial plants, up to November 1, 1935, records of 618 explosions of this character have been obtained. In 187 of these explosions 488 persons were killed and 1,008 were injured. In 504 cases the property loss amounted to more than $49,000,000.

Safety Codes for Dust Explosion Prevention

One of the principal accomplishments in dust explosion control and prevention is the development of safety codes by the Dust Explosion Hazards Committee of the National Fire Protection Association. This committee, composed of representatives from the various industries directly concerned and from insurance and safety organizations, State and Federal officials, and construction and equipment engineers, works under the leadership of the Chemical Engineering Division of the Bureau of Chemistry and Soils.

The following safety codes, have been adopted by the National Fire Protection Association and the National Board of Fire Underwriters and approved as "American Standard" by the American Standards Association:

1. Flour and feed mills.
2. Sugar and cocoa pulverizing.
3. Pulverized fuel installations.
4. Terminal grain elevators.
5. Starch factories.
6. Coal pneumatic cleaning plants.
7. Wood flour manufacturing establishments.
8. Spice grinding plants.
9. Wood working plants.
10. Use of inert gas for fire and explosion prevention.

These safety codes, published by the Bureau of Labor Statistics of the U.S. Department of Labor as Bulletin No. 562, entitled, "Safety Codes for the Prevention of Dust Explosions," have been very helpful in the application of measures for the prevention of dust explosions and fire.

Dust Explosions during Fire-Fighting Operations

Although explosions occur during the normal operation of industrial plants, there have been a number of disastrous explosions during fire-fighting operations. In general these may be classed as follows:

1. Dust explosions that have taken place when firemen attempted to remove the contents of bins or other enclosures. These materials usually are in powdered form and can be readily ignited when they come in contact with a flame.
2. Explosions that have occurred after the fire started, in some instances after the firemen have been fighting the fire for thirty minutes or more. The falling of the floor or the dropping of the bottom of bins forces the dust cloud on to the fire, and an explosion results.
3. Explosions that have been caused by a heavy stream of water striking a pile of powdered material in the plant. The water forces the dust on to the flames of the fire, and an explosion follows.
4. Another classification which is somewhat different from the three already referred to might be considered. Some explosions have taken place during fire-fighting as the result of the chemical reaction between the water and the dust. In the application of water to hot aluminum powder, for example, free hydrogen gas is generated and can be ignited by the flames from the fire. When dusts of this character are present, the use of water in fighting a fire of this type is dangerous.

As the result of the work on dust explosion prevention, the Bureau of Chemistry and Soils has been able to recommend precautionary methods that have proved helpful to the firemen in fire-fighting operations.

Importance of Research Studies on Dust Explosion Prevention

Although considerable progress has been made in the United States and Canada in the control and prevention of dust explosions in grain-handling and milling operations, it must be admitted that all the causes of dust explosions are not known. Dust explosions may occur in an industrial plant as a result of some newly developed process or from the installation of some new type of mechanical or electrical equipment. Many of the recent dust explosions in the United States have been directly associated with the introduction of new manufacturing processes which have opened up additional sources of ignition and resulted in conditions favourable to explosions. It is therefore highly desirable that new manufacturing operations be carefully examined to detect possible dust explosion hazards, and that attention be given to the adoption of preventive measures.

Research work on dust explosion and fire prevention has as its object the development of methods and appliances for the protection of foodstuffs, property and human life.

The practical application of the results of this research work has already resulted in a marked reduction in losses from dust explosions and resulting fires in the principal grain and milling industries in both the United States and Canada.

THE CANCER PROBLEM

Burton T. Simpson

Dr. Simpson described the process by which normal cells divide and mature, and pointed out that the cancerous growth was simply a reversion to the meristematic actively-dividing condition of a group of cells in tissues where the cells should be mature. The relative ease with which the cells of different individuals return to the meristematic condition, he believed to be a definitely inherited characteristic. The stimulus which is responsible for the reversion varies in individual cases and in many instances is not well understood. In other cases it has been experimentally demonstrated that chronic irritations long continued, are the cause. This is true, for instance, in the experimentally induced coal-tar cancers of mice, of pipe cancers in man, and of bladder cancers in analine dye workers.

Dr. Simpson stressed the fact that cancer is readily curable by surgery, radium or X-ray, if recognized and treated in time. The tragedy of the situation, however, is that in many instances its beginnings are not at all painful, and the physiological disturbances caused, are so slight they are ignored. He believed the enormous death rate from cancer could be cut in half if people would pay more attention to chronic irritations, and submit to periodic examinations by competent medical authorities.

WITH A MOVIE CAMERA IN EAST AFRICA

FRANK PULLEN

On Saturday, January 11th, Mr. Frank Pullen of Oakville gave an address, illustrated by moving pictures, of an expedition or safari in British East Africa, starting from Nairobi in Kenya Colony November 30, 1933, and returning in February, 1934, having travelled approximately 2000 miles through the game district of Tanganyika Territory. He was accompanied by Major G. H. Anderson as guide or white hunter and from 15 to 20 natives. Mrs. Pullen and Mrs. Anderson joined the party early in 1934 and spent approximately five weeks in camp.

The lecturer commenced his address by explaining the difficulty of photographing game animals, particularly those that might resent undue familiarity, such as elephant, rhinoceros, and in some cases lion, and explained that for an amateur, the vagaries of the light and other handicaps make it difficult to obtain good results. The films showed a large number and variety of game and other animals, including elephant, rhinoceros, buffalo, lion, leopard, numerous varieties of antelope, zebra, hyaena, jackal, baboons and monkeys, etc., as well as some of the bird and insect life, and in addition, views of native life and the general appearance of the country.

The lecturer pointed out the extraordinary formation of the Rift Valley and the wonders of Ngorogoro crater, an extinct volcano 9000 feet above sea level some twelve miles in diameter with precipitous sides, and explained that on account of the prevalence of game animals at certain times in the year the crater has been made a game sanctuary and no shooting allowed there.

Mr. Pullen expressed his admiration for the lion, of which a large number were encountered, pointing out that, contrary to general impressions, there is little to fear providing they are not molested or driven to extremity by hunger. In other words, the lion is a gentleman. In his opinion, photographing elephants is a difficult and rather dangerous business. He stated that he felt sorry for the rhinoceros which does not belong to this age. He is rather stupid and does not seem to understand what it is all about; has a bilious disposition and is likely to charge one on sight, creating a situation which is sometimes very awkward and quite dangerous. Buffalo are nasty customers when hunted, being cunning and vicious. This would also apply to leopard.

The lecturer stated that the danger of African travel, camp life, and hunting, has been greatly exaggerated by some of the travel films and in many cases artificial situations have been created in order to produce the necessary thrills. He mentioned that with reasonable caution and care not to take a chance, there was little to fear. If however you wounded a dangerous animal and followed it into the bush, you were asking for the trouble you would most certainly get, but, he stated, these animals have a right to live, and if they hit back, they are quite entitled to do so.

Judging from the photographs and the lecturer's description, British East Africa would seem to be a naturalist sportsman's paradise. The quantity of game and infinite variety of wild life must be seen to be believed. Camp life appears to be most comfortable and everything is splendidly organized. The native servants are industrious and reliable.

The plant life and vegetation is most interesting and the films showed large areas of country quite park-like in appearance. Other views showed great open spaces resembling our prairie country. The climate was explained as not too trying, due to the relatively high altitude. Care must be taken however during the heat of the day. The nights are delightfully cool and there is usually a breeze. Snakes are not the frightful menace that people have been led to believe they are.

Mr. Pullen was particularly impressed with the game laws and regulations in effect and expressed his admiration for the manner in which the law is enforced regardless of fear or favour by the English officials, assisted by native game scouts. The motor car is a great menace to the game, but there are heavy penalties for shooting from or in the neighbourhood of a motor vehicle, and it is hoped that the law may be altered so as altogether to prohibit the use of motor vehicles in certain of the game districts. He said that the assistance and courtesy extended to his party by the different officials and the kindness and hospitality they met with in all directions was most outstanding, and that he looked forward to an early return to that delightful country.

The great fear at the moment is that Tanganyika Territory, at present governed by England under a mandate, may, due to political expediency, be handed back to Germany. In that event, the outlook for the wild life, as well as for the native population, is difficult to predict, quite apart from the loss that such a wonderful game country would be to the Empire.

In conclusion, Mr. Pullen pointed out what a very valuable asset the game animals and wild life are to East Africa, stating that in his opinion this asset should not be measured altogether from a commercial

point of view, but should be considered as a heritage that must be safeguarded and handed on to posterity, and he expressed the hope that the people of Canada might be brought to realize what our game animals and wild life mean to this country.

A MEDICAL STUDY OF FAMOUS PEOPLE

W. L. Holman

I believe all of us are Hero Worshippers at heart. We all intuitively feel that every great Civilization has as its living, throbbing nuclei great men. Civilizations have developed, grown great and survived, or have declined and fallen, in direct relationship to the opportunities offered those who have turned from the easy path of mere imitation into the high road of originality—the opportunities for the growth and survival of all sorts and conditions of genius.

It is all too well known that great wars have cut off many, and wars are but diseases of the body politic. But worse than all wars have been the infectious diseases. However, mere statistics are cold and do not strike fire. The history of great people on whom rests the fame of nations, may help to make us appreciate just what this war against disease really is. I will tell you of some of the awful defeats of the past, but I wish also to emphasize that within the memory of many of you have come stupendous victories. It is these victories—the saving of our choicest manhood—that form the very bases of our rapidly expanding civilization. Do not, however, forget the lesson taught by history that the waste of genius through ignorance was a potent factor in the unsteady growth of civilization in the past. The price of one modern battleship would richly endow hundreds of medical researches, and would help to make assurance doubly sure that the everlasting war between mankind and the bacteria will be fought with fuller knowledge.

Following the discovery of bacteria there came great advances in hygiene, preventive medicine and treatment, and this is directly reflected in the extension of human life and incidentally in the greater possibility for genius more often to fulfil its destiny. With knowledge has come the belief that man as part of nature can help to direct nature's laws by understanding them. "The survival of the fittest" has become a catch phrase rarely understood. The elements of fitness must be known. Resistance against infection is certainly not a necessary prerequisite of greatness, nor is an excessive susceptibility a characteristic. Genius shares with the common herd "the thousand natural shocks that flesh is heir to"—no more—no less. Surely those who sweep the race forward to greater things are fit to survive. A friend of mine was walking in the city of Oxford with Sir William Osler. Sir William called his attention

to a man across the street and said: "Do you see that old gentleman? Well, I receive most of my stipend from the University for keeping him alive until the great dictionary is finished." The old gentleman was Murray of the Oxford Dictionary. In this story you will find my thesis.

The biographical sources have been many and well documented or lacking in pertinent facts, but all are teeming with human interest. The average age of mental virility is about 50, but it varies widely. Titian in the full height of his creative power was struck down by the Plague at 99. The hope of the future lies in having available hosts of trained searchers who are questing on the outer borders of wisdom for new discoveries, new inspirations, new ideas, and the finest duty of the state should be to see to it that they are not destroyed by preventable disease before their blessed moment comes. Emerson has said: "Give me health and a day and I will make the pomp of emperors ridiculous."

I have chosen the following persons to illustrate what an incalculable loss the world of the past has suffered from preventable ill health and premature death and have added a few brilliant examples of famous people whose very names would be perhaps unknown had they not lived into their years of fulfilment after the age of fifty.

Louis Pasteur, father of Bacteriology, had paralysis at 46, but all the work which made him famous came long after his recovery. Prince Albert died of typhoid in 1861, at 42 and ten years later Edward, Prince of Wales, was very ill with typhoid but recovered. Wilbur Wright (1867-1912) died at 45 of this disease. Dysentery killed Sir Francis Drake at 50 and Pere Marquette in 1675 at 38. Cholera was the cause of death of Tschaikowsky (1840-1893) just after the first performance of his Pathetic Symphony, also of Hegel (1770-1831) and Carnot (1796-1832) at 36, who wrote a classic on thermodynamics.

Plague perhaps the greatest horror in history has taken a terrible toll. Petrarch's Laura, "the crown of his life", fell under the plague in 1348. John Fletcher (1579-1625) of Beaumont and Fletcher fame died in London at 46. (Beaumont died at 32 from tuberculosis in 1616.) Andrea del Sarto (1485-1531) died in Florence at 45, and Hans Holbein (1497-1543) in London at 46.

Typhus, Jail or Famine Fever, closed the life of Franz Schubert (1797-1828) at 31 and Ricketts (1871-1910), after whom the causative agent was called Rickettsia, died while studying the disease. The loss of life from smallpox in many royal families was very great. The Duke of Marlborough lost his only son at 17 in 1703, and Benjamin Franklin lost a fine boy at 4. Henry Gray (1827-1861) of Gray's Anatomy died when only 34.

Tuberculosis, the most accurately diagnosed disease in history caused

the death of the following: John Harvard in 1638 at 31; Paul Potter the Dutch painter in 1654 at 29; Spinoza at 45 in 1677 from tuberculosis following silicosis contracted in his earlier life from polishing lenses; Purcell (1659-1695) only lived into his 37th year; Wolfe, ill with a renal infection, had only a few months to live when he fell at Quebec at 32; Vancouver died in 1798 when 41; Thomas Girtin, a promising young painter and etcher, a friend of Turner's, died at 27 in 1802; Schiller (1759-1805) died in his 46th year; Jane Austin died at 42 in 1817; John Keats (1795-1821) was killed through ignorance at 26; von Weber (1786-1826) died at 40 in London; the brilliant mathematician Abel (1802-1829) in his 27th year; Simon Bolivar (1783-1830) at 47; Grace Darling (1815-1842) at 27; Chopin (1810-1849) was only 39; Thoreau, the poet-naturalist of Walden died in 1862 at 45; Nordraak (1842-1866) inspirer of Grieg died at 24; Artemas Ward, the American humorist died in London in 1867 at 33; Finsen (1860-1904) was an invalid at 23 and died of a tuberculous peritonitis at 44; Francis Thompson died in 1907 at 48; and Katherine Mansfield (1890-1923) closed her career of great promise when she was 33.

Influenza is not yet fully understood. In the pandemic of 1891-2 Paul Peel died in Paris at 31, and the Duke of Clarence, eldest son of Edward VII who, had he lived, would have been our king, died at 18. Among the victims of heart disease are Bobby Burns (1759-1796) at 37, and Shackleton at 48 in 1922 after influenza. Semmelweis (1818-1865) "the Saviour of Mothers" died, after entering an insane asylum, from an infected finger at 47. Hertz died after a chronic blood poisoning in 1894 when only 37. Rupert Brooke died in the Great War in 1915 from a boil on his lip at 28.

Thomas Hobbes, Bacon, Locke the philosopher, De Morgan, Titian, Tolstoi, Kant, Newton, Anatole France, Charles Darwin, Turner and many others did their great work after 50.

If any of my listeners have names of famous people with interesting medical histories, will you please send them to me. To-day we are living longer and healthier lives but the good work must go on and on.

TWO ANCIENT COUNTRIES—ONTARIO AND EGYPT

C. T. Currelly

There are interesting possibilities in the contrast of the civilizations of Ontario and Egypt. The North American Indians, descended from an Asiatic people who came across the Bering Straits and finally into Ontario, were without doubt quite as good men as the people who drifted into the valley of the Nile. The difference between the two was a question of what they met.

The Egyptian met a swampy land of no great size, a narrow strip bordered by two great deserts. Though the land received one soaking of water, irrigation was a necessity. He had practically no timber, very little game. Nature gave him nothing but a small quantity of land. From this was developed the necessity of specialization of labour, as the free land soon gave out; and with the power of one man to control another man's work by refusing what he made, there developed competition on the one side and on the other the value of storing grain and other necessary products. So a great civilization evolved, the civilization that gave a start to all the western part of the old world.

The Indian of Ontario met with an enormous country of rich land, watered from the heavens; instead of being in a narrow strip, it was in a solid block. Game and fish were everywhere, wild food plants were abundant, and timber was unlimited. Consequently, living was very easy, and there was neither the control of one man's work by another nor any virtue in the storage of grain or other necessary things. The result was that, as far as we know, no development was ever made in this province. Each group that came in brought with it certain things, certain conditions of life, and within Ontario it is a question if anything was ever developed.

A NEW DINOSAUR KINGDOM

BARNUM BROWN

Dr. Brown reminded his audience that dinosaurs were cold-blooded air breathing reptiles that dominated the great land masses of 140 million years ago. Fossil history indicates that they came in during the Triassic Period, flourished throughout the Jurassic Period and declined in the Cretaceous Period. They were extremely variable, ranging from giant forms, more than 100 feet in length, down to small forms scarcely larger than a sparrow.

Dr. Brown's lecture dealt primarily with the American Museum-Sinclair Expedition to Montana and northern Wyoming in 1931-1934. With slides and motion pictures, Dr. Brown illustrated how such an expedition is organized and the technique that is used in spotting fossil remains, removing them from their natural position, and preparing them for shipment to the museum. As a result of these expeditions, the second largest accumulation of dinosaur skeletons has been assembled; a great deal has been added to our knowledge of the life and habits of these interesting animals and 16 types new to science have been found.

THE STORY OF SUGAR CANE

LESLIE C. COLEMAN

Sugar cane or *Saccharum officinarum*, is a large grass. There are a number of wild species of the genus *Saccharum* found commonly in India and throughout the Malay archipelago, and some of these resemble sugar cane rather closely. It seems probable that cultivated sugar cane arose as a single mutation or a series of mutations from one or more of these wild species.

The first definite reference to sugar cane is the report sent back by generals of Alexander the Great's army invading India speaking of "a reed which produces honey without the aid of bees." This was written in the year 327 B.C. and would seem to indicate that at that time the manufacture of sugar from the cane had not developed farther than the evaporation of sugar cane juice probably in the sun to a semi-solid mass resembling crystalline honey.

From India the cane was carried (about 600 A.D.) to areas bordering the Persian Gulf where monks of the Nestorian Church developed a process of refining sugar. By the middle of the 7th century the Arabs had, in their drive to the west, carried the cane to Egypt, and later from there along the southern shores of the Mediterranean to Sicily and to Spain. In the 12th century Spain was one of the most important sugar-producing countries of the world and the industry has continued there up to the present day.

During the 15th and 16th centuries the Portuguese and Spanish carried sugar cane and sugar manufacture to the New World via Madeira, the Canaries and Cape Verde Islands. Columbus carried cane to Hespaniola (the present island of Haiti) on his second voyage in 1493. This led gradually to the decline of the Mediterranean industry till towards the end of the period it had practically disappeared. From the 17th century to the present there has been a steady expansion of the industry in the west, more especially in West Indies (Cuba, Porto Rico, Trinidad, British Guiana), United States and the Hawiian Islands, which has been accompanied during the past century and more especially the last fifty years, by an almost equal development in the east (Java, the Philippines, Mauritius, South Africa, with Australia and Formosa). The expansion in both west and east was accompanied and partly conditioned by the introduction of new and better varieties, chiefly from the South Pacific Islands.

The most important of these was the one brought by Capt. Bligh from Tahiti to the West Indies in 1791. The accompanying tables give in concise form world sugar statistics as far as that produced from sugar cane is concerned:

TABLE I

WORLD SUGAR PRODUCTION

Cane sugar	1913-14 Tons	1929-30 Tons	1935-36 Tons
Total in America	5,001,097	9,483,983	7,575,500
Total in Asia	3,953,728	7,381,557	7,987,933
Total in Australia and Polynesia	353,379	620,271	742,000
Total in Africa	480,956	732,635	942,000
Total in Europe (Spain)	7,376	13,562	18,900
Total cane sugar production	9,801,536	18,232,000	17,266,333
Total beet sugar production	8,634,942	9,156,799	9,256,500
Grand total, cane and beet sugar	18,436,478	27,388,787	26,522,833
Canada—beet sugar production	11,675	27,869	67,000

TABLE II

PRODUCTION OF SOME OF THE MAIN COUNTRIES PRODUCING CANE SUGAR

	1913-14 Tons	1929-30 Tons	1935-36 Tons
United States	268,337	190,235	315,000
Porto Rico	325,021	773,310	800,000
Hawaiian Islands	550,925	825,891	900,000
Cuba	2,597,732	3,122,186	2,500,000
British West Indies and Demarara	252,458	384,088	500,600
British India*	2,291,500	2,761,000	5,300,000
Java	1,272,417	2,923,010	487,933
Formosa and Japan	157,050	923,873	1,250,000
Philippine Islands	232,761	773,674	950,000

*The product is mainly a very crude sugar consumed in an unrefined state.

From these tables it will be seen that, at present, about two-thirds of the world's consumption of sugar is derived from sugar cane, and that India is the largest producer of sugar cane and sugar although she, at the same time, is not yet able to supply her own needs in this regard. The figures further show that within the past five years the flourishing industry of Java, probably the most efficient in the world, has been almost ruined, owing of course to the imposition of high tariffs in every important sugar importing country in the world. Behind these walls of economic

nationalism industries are being built up in countries such as India and Japan (Formosa), formerly consumers of Java sugar. The Philippines and the Hawiian Islands have retained their industries intact or even expanded them owing to their favoured position in the large United States market, while Cuba's industry has been saved from complete ruin by favourable tariff arrangements with the United States, Cuban sugar paying half the regular duty.

Turning to a consideration of sugar cane production and sugar manufacture in various parts of the world, the lecturer dealt with the highly mechanized system in vogue in the Hawaiian Islands where wages are high, the conditions in the West Indies, and the unique industry of Java, where, owing to the peculiar conditions of land tenure and the dense population, we have hundreds of thousands of acres cultivated almost entirely by hand. These seemingly primitive methods yield under careful scientific supervision astonishing results, the average production over the whole area under Dutch control being approximately six tons of sugar per acre. Hand cultivation is coupled with the most modern machinery and methods of transport and manufacture so that Java has a lower cost of production than any other country in the world. Nevertheless the industry is being killed by high protective tariffs in the countries which are Java's natural markets.

From this general survey the lecturer turned to the work with which he had been intimately connected for a quarter of a century. He dealt with the organization of scientific work in a country, India, where agriculture still stands at a very primitive level and where up till comparatively recently equally primitive methods of sugar manufacture prevailed. Many of these had changed but little during the past thousand years. The work consisted of most carefully planned experiments in plant-breeding, including such modern methods of inducing changes in plants as the use of X-rays, and similar experiments in cultivation and manuring. Thus when the completion of a large irrigation scheme made imperative the introduction of new crops and methods into an area which had been previously backward, it devolved upon the lecturer to develop a sugar industry from the ground up.

This work had to be accomplished within a period of two years. The erection of a sugar factory capable of producing 50 tons of sugar a day and the training of a staff had to be synchronized with the growth of an area of 3,000 acres of sugar cane by some 600 small farmers, none of whom had any previous experience of its cultivation. Coupled with this was a further task of erecting a distillery to utilize as fully as possible the waste molasses, the alcohol produced being used largely for driving tractors, trucks and locomotives required in the development of the industry.

Thanks to careful planning and a capable and loyal agricultural staff, the task was successfully accomplished. This industry, the first of its kind in the state of Mysore, promises to be one of the most important in India and to be profitable alike to the agriculturists, the shareholders and the state, which, incidentally, has retained a controlling interest.

The lecture was fully illustrated by coloured lantern slides.

THE CONSTRUCTION OF BOULDER DAM

George O. Sanford

During the past thirty-four years the Bureau of Reclamation of the United States Department of the Interior has constructed 133 storage and diversion dams. Four times it has built the highest dam in the world. First, in 1910, it constructed the Shoshone Dam in Wyoming, 328 feet high, then the world's highest. Next, in 1915, it built the Arrowrock Dam in Idaho, 349 feet high. Third, in 1932, it completed the Owyhee Dam in Oregon, 406 feet high. The fourth dam constructed to unprecedented height is the Boulder Dam on the Colorado River, where it forms the dividing line between the States of Arizona and Nevada. This dam, completed last year, rises to a height of 727 feet.

The Boulder Canyon Project was authorized by an Act of Congress approved December 21, 1928. The cost was estimated for Boulder Dam, its power plant, and the All American Canal, the three principal engineering features making up the project, at $165,000,000, this including interest during the construction period. This vast project involved much more than merely the construction of the highest dam in the world. Its completion marks the conquest of the Colorado River, making a useful servant of a turbulent and dangerous stream which for many years had caused damage because of its periodical and destructive floods, and because at other times it dwindled to a trickling stream, insufficient to supply the irrigation requirements of lands in Arizona, California and Mexico, which were dependent upon it. Construction of Boulder Dam has eliminated the flood menace, and through storage of the flood flow in its reservoir, has insured an adequate water supply to all the downstream lands that are susceptible to irrigation.

Under the provisions of the Boulder Canyon Project Act, no money could be expended for construction of Boulder Dam until pending contracts had been entered into for the sale of electrical energy at rates that would repay the cost of the dam and appurtenant works, together with interest at 4 per cent within a 50-year period. Contracts were executed with the City of Los Angeles, the Metropolitan Water District of Southern California, the Southern California Edison Company, and others, for the sale of the power. Actually the government does not sell electrical energy, but has contracted for the sale of falling water at rates which, when translated into electrical energy, delivered in the vicinity of Los

Angeles, will equal from $3\frac{1}{2}$ to $4\frac{1}{2}$ mills per kilowatt hour, depending upon the load factor. On this basis, the value of the falling water for firm power is 1.63 mills per kilowatt hour. The price for surplus power has been fixed at one-half mill per kilowatt hour. It is estimated that when the power plant is fully equipped, the annual receipts from the sale of power will approximate $7,300,000, an amount sufficient to repay the cost of the dam and power plant with interest at 4 per cent, making payments to the States of Arizona and Nevada of about $608,000 each, annually, return to the federal treasury with interest at 4 per cent over a 20-year period the sum of $25,000,000 allocated to flood control, and in addition, leave an accumulated surplus for future development in the Colorado River Basin of about $64,000,000. These figures are based upon rates as fixed in repayment contracts actually signed before construction began. The Boulder Canyon Project Act provides that the rates are to be subject to readjustment at 10-year intervals.

The Government was ready late in 1930 to call for bids for the construction of Boulder Dam and power plant. The contract was awarded to the low bidder, a specially organized combination of six construction firms which called itself Six Companies, Inc. The contract called for payment to the contractor of about $50,000,000 for labour and supplies. The Government furnished all the materials required in construction of the dam.

The second contract for fabrication and installation of the steel penstock pipes was awarded to Babcock and Wilcox Company, whose principal plant is at Barberton, Ohio, the estimated value of their contract being $12,000,000.

Work was started March 11, 1931, and on the last day of February, 1936, the contractor turned over to the United States the dam and power plant completed except for the installation of power machinery. This construction had been completed more than two years in advance of the time specified in the contract.

The Bureau of Reclamation is to install the hydraulic turbines and generators, and the first unit in the power plant will be ready for operation in September, 1936. The construction was divided into five operations. The first of these was the building of a city by the government to house those working on the dam. With the intense heat that prevailed during the summer months in the desert country adjacent to Black Canyon where Boulder Dam was to be built, it was necessary to provide the best possible living conditions for the construction organization. This was done at a cost of approximately $1,700,000 by the construction of Boulder City, Nevada, a government town. It was about fifteen months in construction. It has water and sewer systems, paved streets, electrified

modern homes, and landscaped parks. It is about seven miles from the dam on high ground about 2,000 feet above the river where a good source of air was obtained and where conditions made it possible to live with some degree of comfort even during the months when the temperature ranged up to 125 degrees in the shade. An excellent supply of water was obtained from the Colorado River after it had been desilted, softened and purified. It proved to be very difficult water to treat and about 75 tons of chemical were used each month. Careful consideration was given to the health of the men. It was found that in treating the large quantities of water required in this extremely hot and dry climate, it was advisable to add a little salt to the drinking water to help replace the soluble salts removed from the body by perspiration. This discovery all but eliminated heat prostrations at the dam.

The second major step in the construction of the dam and powerhouse was the completion of four diversion tunnels, excavated to 56-feet in diameter and about four thousand feet in length. The third step was the construction of the upper and lower cofferdams by which the river was turned through the diversion tunnels and the actual damsite dried up. This operation also included excavation of the site of the dam in the canyon. The fourth major operation was the actual construction of the dam and its appurtenant works and powerhouse. The fifth and last was the installation of the power machinery. All of this work was carried on with a maximum of speed and efficiency.

The contractor installed a thoroughly modern plant at an estimated cost of about $7,000,000. The work was prosecuted with three shifts, 24 hours a day throughout the entire year. The mass concrete going into the dam consisted of about one part of cement to 10 parts of sand, gravel and cobbles. Nine-inch stones were the largest used. This concrete was carried in steel buckets having a capacity of eight cubic yards and weighing, when filled, about 20 tons.

It is of interest to note that the cubical content of Boulder Dam is almost exactly the same as the great pyramid of Cheops, each containing approximately 3,400,000 cubic yards of masonry. Herodutus, the Greek historian, tells us that it required 100,000 men 20 years to complete the great pyramid, whereas Boulder Dam was constructed by about 2,000 men in a period of approximately 20 months, so that the efficiency of one man plus modern machinery to-day is equivalent to 150 men in the time of Pharaoh.

The pictures of the dam show it being constructed in blocks, or more properly, columns, each 25 to 60 feet in plan dimensions. The concrete is added in layers of five feet at a time and then permitted to set. One of the major problems connected with the construction of Boulder Dam

was the removal of the excessive amount of heat that generated in the concrete during the chemical process of setting which, with the low heat cement rose to about 100 degrees temperature and with normal cement as high as 130 degrees. It was estimated that if no special steps were taken to remove this heat it would require about 150 years to cool to its final temperature, and during this time the concrete would be shrinking and cracking. To artifically cool the concrete to the required temperature within a reasonable period, 1-inch steel pipes through which cooling water was circulated were installed. The temperature of the lower upstream face of the dam was reduced by this cooling process to 43 degrees, and on the upper downstream face to 72 degrees. This was accomplished in a period of about five months. All told, there was required about 570 miles of cooling pipe, an equivalent of 1,740 tons of refrigeration per month was used in the refrigerating plants which cooled the cement. This resulted in the forming of cracks at contraction joints which had been left in the dam. A second system of pipes was installed through which cement grout was forced into these cracks, making a solid mass of concrete masonry between the canyon walls.

It is difficult to grasp the size of Boulder Dam because of the enormity of its surrounding canyons and mountains. This applies with equal force to the power plant, each wing of which is more than 600 feet long and of a height equivalent to a twenty-story building. In this plant there will be installed 17 hydraulic turbines and generators having a rated capacity of 1,835,000 horsepower, the largest installation in the world. Electrical energy is generated at 16,500 volts and stepped up to about 287,500 volts for transmission over the three-phase transmission lines extending 240 miles to Los Angeles and vicinity.

From the gate towers back of the dam, which are 70 feet in diameter at the base, rising to a height of approximately 384 feet, the steel penstock pipes extend to the hydraulic turbines in the power plant. These pipes start with a diameter of 30 feet and under maximum pressure have a thickness of $2\frac{3}{4}$ inches. The steel for these pipes was shipped in as flat plates, 12 feet wide and about 31 feet long. The pipe itself was manufactured at the damsite, three plates being welded into a completed ring and then two rings electrically welded together making a completed section about 24 feet in length. These sections were then installed in the penstock tunnels and fastened together by cold rivets, the largest of which were three inches in diameter and six inches in length. The installation of these penstock pipes is being carried on in a very satisfactory manner and will be completed in advance of the time specified in the contract.

The storage of water back of Boulder dam was first started February 1, 1935, and it is expected that the reservoir will be filled to about one-

third of its capacity of 30,500,000 acre feet in 1936. This, the world's largest artificial lake, has been very properly named Lake Mead, to commemorate the efforts of Dr. Elwood Mead, late Commissioner of the Bureau of Reclamation, in carrying this gigantic engineering project to successful completion.

A SCIENTIST IN THE ANTARCTIC

GRIFFITH TAYLOR

In introducing the subject, Professor Taylor showed by illustration some of the many difficulties encountered while exploring in the Antarctic.

Reconnaissance surveys to date present a general knowledge of existing conditions, but many points of major importance remain to be solved. It is not clearly determined whether the Antarctic, an area of 5,000,000 square miles, consists of one or two continents.

Some detailed surveys have disclosed much important information and such features as semi-active and ancient volcanoes, the positions of the true south pole and the magnetic pole, and heights of land have been mapped and recorded. Meteorological stations, placed at strategic points to record existing weather conditions, have located a large low pressure area south of latitude 40 degrees which causes severe windstorms, which undoubtedly affect the climate of the southern continents. Wind velocities up to 107 miles per hour have been recorded.

Generally a glacier-covered plateau type of topography exists, abruptly cut off by an escarpment which rises to heights of 10,000 feet and remains as a prominent topographical feature for some two thousand miles.

Oceanographical studies have revealed a remarkable submarine mountain range which appears to connect the ranges of the Andes with the Antarctic. From the similarity of existing animal life (*Marsupialia*), a theory that Australia and America were once connected through the Antarctic has been suggested. However, Professor Taylor is of the opinion that migration was by way of Asia to these continents, rather than across Antarctica.

Life within the Antarctic circle is limited by cold and lack of vegetation, and is migratory, with two known exceptions. The migratory life consists of diatoms, shrimps, penguins, seals and "killer-whales", to which the speaker humourously referred as constituting a protoplasmic cycle. The only life at home in the region is the wingless mosquito which lives just within the confines of the Antarctic circle, and a minute form of life (*Gomphocephalus*) whose habitat is as far south as 78°S.

Professor Taylor showed the possible relationship between the known large precambrian areas and that surrounding the south pole, and showed

that an almost complete geological section was to be found in Antarctica. The sedimentary beds are partly faulted and in some places tilted, but no major folding has taken place. Coal is abundant and because of its position in a relatively undisturbed belt, represents one of the largest potential coal fields in the world to-day. The presence of coal and certain fossils (corals), and the lack of indications of former ice ages, suggest that the temperature was formerly comparatively mild.

One of Professor Taylor's many problems was to study the effects of glaciers on land surfaces. At present the weather is too cold to allow the necessary melting and consolidation to produce movement, although cirques and glaciers have brought about some erosion.

To date, only whaling, controlled by Great Britain, makes the Antarctic economically important. Professor Taylor commended the action of the British Government which levies a tax on all whaling in Antarctic waters and uses the proceeds largely for biological research in the area. Future exploration will depend almost entirely upon donations, and in closing Professor Taylor asked for the co-operation of the public in making this research possible.

ALASKA AND THE STIKINE

FRANK OASTLER*

Abstract of address delivered by Dr. Frank Oastler of New York, on Saturday evening, February 29th, 1936, in Convocation Hall.

(Prepared by George F. M. Smith)

Alaska was bought from Russia by the United States of America in 1865. It is truly a country of extremes and contrasts. In the winter the temperature may be −40 degrees F., and in the summer 120 degrees F.

One of the main aims of Dr. Oastler's expedition was to observe and photograph the Stone's sheep (*Ovis stonei*), and also the Rocky Mountain goat (*Haplocerus montanus*). From Vancouver the trip was made by steamer up the coast by the inside passage, to the Stikine River. Of this river one hundred and sixty-eight miles are in Canadian territory, and thirty-eight miles are in Alaska. The trip up the Stikine takes two and one-half days but the return trip requires only half a day, owing to the swift current. During the first part of the trip the most common bird seen was the glaucous-winged gull. The head of navigation on the Stikine is a Hudson's Bay post. In this region Sitka spruce, hemlock and cottonwood trees are abundant. The immediate goal of the expedition was Coolidge Mountain which is the home of the sheep and goats. Throughout the lecture all references to wild life, both plant and animal, and to the geological formation and glaciers, were well illustrated by beautifully coloured lantern slides.

On the return trip the expedition passed the North Sawyer glacier. Here both black-backed and short-billed gulls were abundant. Admiralty Island, the home of the Alaska brown bear, was visited. Several remarkable photographs of this very large bear were obtained. At the time of the salmon run these bears feed on the spent salmon found dead in great numbers along the sides of the stream.

The expedition left for the Gulf of Alaska by steamboat and from there journeyed to Prince William Sound. In this part of the trip, to Mount McKinley, the largest and most magnificant glaciers were seen. Columbia, Harvard, Yale and many other glaciers in this region were named by the Harriman Alaska Expedition. The nest and eggs of the rare surf bird were found. Professor Dixon of California was the first to investigate these birds but the lecturer was the first to find the young.

*Dr. Oastler died on August 2nd, 1936.

Nests of the golden plover and the long-tailed jaeger were found. The latter bird is a common Pacific Coast form, but it nests in the interior of Alaska. Excellent photographs of the Dall's sheep (*Ovis dalli*) from Mount McKinley were shown. These sheep feed in the morning and evening but retire to higher rocky and barren ground in the afternoon and at night.

The last part of the expedition's trip was into the Kenai peninsula to observe the moose and foxes. Photographs of the blue fox and the silver fox were shown. These photographs must have been exceedingly difficult to obtain. They were additional examples of the high standard in natural history photography that Dr. Oastler has set for himself.

MAN'S LAST SPECTRE

(*Mental Disorders*)

C. M. Hincks

Disabilities of the mind are worthy of our consideration because they are wide-spread—they are crippling and constitute one of the threats to personal and national efficiency.

That mental disorders are surprisingly prevalent is rendered evident by such facts as these: Take insanity—that large grouping that includes the most dramatic and the most pronounced forms of mental breakdown. Our mental hospitals in Canada harbor no less than 30,000 cases. Indeed, there are more occupied beds in our mental institutions than there are occupied beds for cases of physical diseases in all our general hospitals put together. One single form of mental disease—*dementia praecox*—is responsible for more chronic invalidism than either tuberculosis or cancer. And we can predict, on the basis of past experience, that 4 children out of every 100 born in this country will, in the absence of adequate arrangements for prevention, eventually enter mental hospitals as patients—almost as many as will graduate from our Canadian universities.

In considering prevalence we must also reckon with another type of disability — with feeblemindedness or mental deficiency — a condition characterized, as you know, by a stunting of mental development—a condition where the individual may grow to adulthood physically while remaining a child mentally. Two per cent of all children belong to this category lacking the potentiality for normal mental growth.

And to get a picture of the dimensions of the problem of mental disorders we must include in our listing so-called nervous conditions—hysteria, neurasthenia, nervous breakdowns and so on—conditions that do not cripple the entire personality as in insanity—but that nevertheless make great inroads on human happiness and efficiency. These nervous ailments rank only second to the common cold in prevalence.

Finally we must add epilepsy. We must add the hosts of individuals with lopsided personalities and those who have disabilities that are labelled as physical but that are intrinsically mental as well.

Now when we lump all these conditions together—insanity and the rest—we discover that mental disorders are as prevalent as physical disabilities.

Such facts indicate the magnitude of the problem. And questions such as these naturally arise: Has science been successful in developing techniques to elucidate the nature of mental disabilities—to point the way to effective treatment and prevention? What arrangements are we making in Canada for the feebleminded, the insane and the other groups of the mentally afflicted? In looking to the future what lines of development seem to be indicated?

A brief discussion of these points.

To gain an understanding of mental disorders, one method that has been utilized has been the physical approach. And in this regard there have been consistent attempts to discover physical causes that might account for the conditions. Through such studies it has been established that certain toxins as alcohol and syphilis may be significant — that diminished or increased activity of the glands of internal secretion—particularly the thyroid—may play some part. Brain lesions such as tumors and injuries account for some conditions. Various constitutional factors and the state of the physical health may be important.

And as a result of physical studies it has been possible to develop more effective methods of treatment for certain disabilities. This has been true, for example, in connection with a disease known as General Paralysis of the Insane. By the discovery that it was due to syphilis and that an attack of fever tended to bring about improvement, there has been introduced malaria treatment that produces fever, and that makes it possible to arrest the disease in one third of all cases. Previously, patients died in from one to three years and in the end stages of their illness they presented the most pathetic sight in the whole realm of disease.

Another condition that has been successfully attacked through the physical approach is cretinism—a type of feeblemindedness. It was found that deficient thyroid secretion was the cause, and that, by administering thyroid gland extract at an early age, cure could be achieved. I have never witnessed anything more startling than the transformation through thyroid treatment of children who had been slow, stupid, listless with poor muscular co-ordination into active, alert normal individuals. Unfortunately very few cases of feeblemindedness belong to this cretin group.

At the present time two lines of investigation from the physical angle are of considerable interest. One relates to the treatment of a form of insanity wherein the patient may be uncommunicative for weeks on end—apparently in a state of stupor—paying no attention to what is happening around him. Now, by giving large doses of sodium amytal to induce deep sleep, it has been discovered that, upon awakening, the individual may be perfectly normal—his old-time self—cheerful and ready to chat

with his friends. Unfortunately, this remarkable recovery may last only for an hour or two, but further investigation may pave the way for actual cure.

The other line of investigation that I would like to refer to, wherein the physical approach is used, has been made possible through advances in radio engineering. There has been constructed an instrument that will amplify electrical changes in the brain a million fold. This instrument is known as an electro-encephalograph, and, if electrodes are applied to the head, a tracing can be made that records the variations of electrical potentials in the brain. Now these records—these tracings—vary from individual to individual—they show characteristic curves before the onset of an epileptic attack, for example—the tracing is altered if one electrode is placed over a damaged part of the brain. A whole new field of study has been opened up and it is possible that this instrument will be as helpful in studying disabilities of the mind as has been the case with the electro-cardiograph in connection with disabilities of the heart. In jocular fashion we used to say that such-and-such an individual had a brain wave—now we know that brain waves are not a figment of the imagination—they actually exist and we can record them.

Now there is no question that it has been profitable to study mental disabilities at the physical level. More of this work is needed. And in every case a thorough physical examination is always indicated. It must be admitted, however, that up to date it has been found impossible to discover a satisfactory physical basis for the great majority of mental disorders, and we suspect that the doctrine, that a healthy body insures a sound mind, may be only partially true. It should also be stated that although attempts have been made to treat every form of mental illness through surgical operations, through drugs, through glandular extracts and other biological products—nevertheless results have been disappointing except in connection with a relatively few types of disorder.

Since the purely physical approach in the study of mental disabilities has not been sufficient to illuminate the whole field, it has been necessary to make observations from a somewhat different angle. And in this regard we have found it profitable to look upon these ailments as disabilities that relate to the inadequate adjustment of the organism to its environment. We conceive the total organism as a person reacting to his or her environment through the processes of thinking, feeling and acting. Alteration of these processes constitute the phenomena of mental disorders.

Thus you see it has been necessary for us to adopt a psychological approach but since we do not want to relinquish an attack from the

physical angle we combine the two—and give it the name of a psycho-biological approach.

Now we have gained a considerable understanding of mental disorders by viewing them as psychological phenomena—by viewing them as inadequate methods of meeting the demands of life. We discover that some of these disorders are characterized by defective intelligence wherein the individual fails to make the grade, so to speak, because of lack of wit. We find in connection with some other types of mental disorders that the individuals concerned have been the victims of inner conflict, wherein, say, a sense of duty or the demands of the ethical or religious nature point the way to one line of action, and other phases of the individual's nature make an equally strong demand that he pursue an entirely different line of action—and as a result of this internal civil war, the person in question becomes tied up in an emotional state that renders him incapable of carrying on the business of life in an effective way, and the symptoms may include anxiety or depression or restlessness, or other disturbances of the mental life. Cases of mental disorder of this kind were frequent during the world war and were known as "shell shock". They are also of frequent occurrence in times of peace. When pronounced—when the total personality of the individual is affected—the condition may be one of actual insanity. When not so pronounced we refer to the condition as nervous.

There seems to be little question that an enormous amount of mental disability can be ascribed to mental conflict, wherein the problems of life adjustment become too great for the individual to solve and mental disability steps in as nature's way of calling a halt.

Viewed from this angle a mental ailment is beneficent. It represents nature's method of working towards cure. It gives the individual a breathing spell before making another attack upon his problems. It may be as beneficial as inflammation when we get a cut—the inflammation is a summoning of body defences against infection. But inflammation, while it saves lives, may go too far and result in destruction of tissues or even death. And so mental disorders, while protective, may go too far and end in permanent disruption of the personality.

The question may be raised as to whether the theory of mental conflict is borne out by actual controlled experimentation. Here there comes to mind the famous Pavlow experiment wherein a dog was conditioned upon the ringing of a bell to walk across an electric grill and eat a piece of meat. A bell of a different tone, however, conditioned the dog not to eat the meat because when it was rung the electric grill was charged and the dog suffered pain if he walked on it. When a third bell was run with

a tone midway between the other two—the dog developed an actual mental disorder. Apparently he was the victim of inner conflict—with an impulse to eat meat and another equally strong impulse to refrain from eating—and the result—mental disability.

It is interesting to note that not all dogs when subjected to this experiment became disordered. This fits in with human experience—that no matter what the stresses and strains of life—some people are immune from mental disability. The elucidation of the factors that make this immunity possible is a fascinating problem for science.

Mental conflict has been produced experimentally in humans by Professor Luria of Moscow. Under hypnosis he made the positive suggestion to his human subjects that 7 added to 7 makes 15. Upon awakening, the individuals were confronted with a conflict—a conflict between the established belief that 7 and 7 made 14 and the superimposed belief that 7 and 7 makes 15, and there resulted temporary mental disability.

Freud of Vienna has focussed attention on mental conflict and through psychoanalysis has developed a technique of uncovering repressed elements in the mental life that may furnish the basis for such conflict. Freud more than any other man during the last quarter of a century has quickened scientific interest in this field.

The psychological approach in the study of an individual with a mental disability resolves itself into this—reviewing his life history; discovering the nature of his problems and how he has been meeting them; studying his emotional stresses; weighing his intellectual equipment; interpreting his symptoms as natural consequences of difficulty in meeting the problems of life. And treatment may involve simplification of the environment, re-education and re-organization of the patient's life.

This psychological approach is proving its value not only in contributing to an understanding of mental disorders, but is also helpful in elucidating many physical ailments. We find, for example, that in regard to the circulatory system that worry, apprehension and lack of serenity may be of prime importance in abetting high blood pressure, arteriosclerosis, angina pectoris and other heart conditions. In reference to disorders of the digestive tract approximately 50% of the disabilities that come to the attention of the physician are of psychological origin and can best be treated by psychological and educational means as well as medical. Indeed, a considerable proportion of cases seeking the advice of the child specialist, and eye specialist, the surgeon and other specialists need to be studied from this angle.

These facts are stirring medical thought. And we may be entering

upon a new phase of medical progress that will be as important as the era initiated by Pasteur. In this new phase as much attention will be given to the emotional life and the adjustment of the individual, as to germs and to physical processes. Scientific medicine will be humanized to a greater extent than is the case to-day. And among other things there may be broken down the artificial division between mental disorders and physical disorders — some will be viewed simply as having a greater mental weighting than others.

Now a brief reference to two groups of mental disabilities.

First, a word about mental deficiency or feeblemindedness. As I have previously indicated, this is a condition of stunted mental development. The lowest grade types are designated idiots; the middle grade, imbeciles; and those with greater intelligence, morons.

There is no cure. And so, we place reliance on education and supervision. With the higher grade types—with morons—the results achieved through education may be remarkable. For example, 70% of the graduates of one of our Toronto schools for retarded girls are to-day occupying positions of responsibility in household service, in factories, stores and offices. During the depression, they have held their positions better, in many instances, than has been the case with their so-called "normal" sisters.

The reason for success in the education of the feebleminded lies in the fact that their training is in line with capacity and the children learn through doing. By following this method, the interest of each child is maintained at a higher level and the acquiring of skills is looked upon as a joy rather than as a boring task. These children are actually sorry when a lesson is over.

If, in the education of normal children, there were utilized the experience gained with the feebleminded, there is a possibility that efficiency might be stepped up 50% or more. There is a saying to-day that, to get a good education, a child is fortunate if he is feebleminded.

How about sterilization for mental defectives? Low grade conditions —idiocy and imbecility—as a rule are not due to bad heredity. Fifty per cent of higher grade types—morons—however, come from inferior family stock. In selected cases, sterilization would be a godsend—particularly in connection with married girls who have not sufficient intelligence to undertake the complicated task of rearing a family. But, wholesale sterilization as is now practised in Germany, is hardly warranted in the light of existing scientific knowledge.

Now, a word about another great grouping of mental abnormals to be found in our mental hospitals—the so-called "insane", but better

referred to as "psychotic". They are classified to-day into twenty-two groups with many subdivisions. And, therefore, it is practically impossible to give a brief description that would be applicable to all. However, this may be said—insanity or a psychosis does not as a rule manifest itself until adolescence or later. Onset is rarely sudden. Rootages frequently go back to childhood. Recovery is usually slow. The symptoms as revealed in conversation and behaviour may appear meaningless on superficial inspection—or, to use the vernacular, may appear to be "crazy"—but, when subjected to close study, it is evident that the symptoms have meaning. In other words, there is method in madness.

Some of these points are revealed by the following history picked at random from the files of a hospital caring for the mentally ill. The case is that of a twenty-seven-year-old girl with the delusion that she was in love with a man whom she had treated very badly. She believed that people were talking about her and blaming her for unfair treatment of this man. She was somewhat depressed. In looking into her history, it is evident that her illness did not come out of a clear sky. There were rootages in childhood. She had never been able to face life squarely. As a child, she was timid, shy and very dependent upon her mother. She did well at school, but was too reticent to make friends and develop outside interests. She was a victim of periods of day dreaming, mopishness and depression. When she reached womanhood, she longed for romance, but was too shy to make friends with the opposite sex. Her insanity at twenty-seven might be said to be a natural outcome of her dissatisfactions. She had no lover in actual life and so created one in imagination. In other words, her delusion served a purpose in giving her some degree of comfort.

Our chief resource for the treatment of insanity is the mental hospital. Great improvements have been brought about during the last twenty years in making the mental institution a more effective therapeutic agency. To illustrate this, I will direct your attention to a mental hospital I visited in Western Canada eighteen years ago and will indicate the advances that have been made since that time. In 1918, the institution in question had 800 patients. There was only one physician. He had little time for medical work. His chief concern was in regard to the feeding and housing of his patients. There were no trained nurses in the institution—although women paraded around in nurses' uniforms. The male attendants went about without collars. They were a rough crowd of men and, because of the number of black eyes observed among the patients, it was evident that strong-arm methods of control were used. Over some of the beds heavy iron gratings had been placed, giving the

patients the appearance of caged wild animals. Many patients were tied up in restraining apparatus. There was universal idleness—patients sitting in rows, staring vacantly into space, waiting for death as a release. Many of the patients were admitted to the hospital via the jails, although they had not committed any offence against society.

What is the condition at this hospital to-day? There are seven physicians instead of one. There is a training school for nurses. Occupational therapy tends to keep the patients happy and busy and, at the same time, promotes recoveries. Continuous warm baths are used to allay excitement and this treatment renders physical restraint unnecessary. Careful clinical work makes possible a higher recovery rate. The grounds are like a beautiful park and assist in restoring mental health.

For the most part, our thirty mental hospitals in Canada providing care for 30,000 patients, are creditable. While they involve an expenditure of eleven million dollars a year, the per capita costs are less than for prisoners in our jails and one-third the costs for general hospital care. Larger expenditures would make possible more individual attention to patients and this would result in a higher recovery rate.

Another point in regard to insanity and mental hospitals. Relatives delay too long in referring patients for treatment. When treatment is prompt, 66% can be expected to improve, as against 40% when there is delay.

The notion still persists that insanity is always due to bad heredity and, therefore, constitutes an indictment upon the family affected. This is one of the chief reasons for unfortunate delay in sending cases for prompt treatment. There is involved a sense of shame.

What are the facts in regard to heredity? Some families have more than their share of mental disability. Certain forms of insanity tend to be passed from one generation to another. But, if we take mental illness as a whole, we are impressed with this fact—that a neurotic hereditary taint is almost as frequent among normal people as among the insane or, should I say, the insane have almost as good heredity as we possess, and there is no valid reason to look on mental illness as a disgrace.

And now, I would like to raise the question—Is prevention in this field practicable?

In reply, it can be said that we possess sufficient knowledge concerning the causation of many forms of mental disability to warrant the belief that it is practicable to prevent a considerable proportion of mental illness.

Aside from feeblemindedness, individuals are not born with mental disability. Some, however, possess constitutional and temperamental

weaknesses that may act as predisposing factors to the development in later life of mental maladjustment. But, if adequate precautions are taken, many breakdowns can be forestalled.

Now, it would seem that a constitutional and temperamental weakness may reveal itself during childhood by the tendency to remain dependent —to shun independent activity in the making of friends, in the development of interests outside the home, and in the assumption of responsibility for others. Such children may be timid, shy and sensitive, may have feelings of inferiority with a lack of confidence in their own ability to face the world, and may have fears concerning the future, concerning the unknown. While they may possess normal intelligence, these children waver in the necessary process of growing up, a process that implies development in the direction of independence, self discipline and fortitude in meeting the exigencies of life.

If children with sensitive and retiring make-up are exposed to healthy influences in the home and in the school, they may become our most useful citizens. If these influences are unhealthy, however, they may in later life swell the ranks of the mentally abnormal.

In reference to the home, there are among others, three types of parents whose influence upon such children may be unfortunate. The over-solicitous, molly-coddling mother, for example, who over protects, who spoils her children, who slaves for them when they should be looking after themselves, and who does not give them an opportunity to develop independence. Again, there is the dominating father who may crush individuality, and who, in the case of sensitive children, may sow seeds of a feeling of inferiority. Or, there is the changeable parent who is molly-coddling to-day and domineering to-morrow—the parent who creates a chaotic home atmosphere, making it difficult for the child to develop healthy habits.

A fourth type of parent may exert a wholesome influence—the parent who attempts to guide rather than dominate—who gives helpful encouragement in the direction of independence—who acts as a pal and a partner.

A word about the school. It can foster mental health if it encourages children to think for themselves, to take their part in group activities, to develop hobbies and interests that will enrich their lives, and to assume responsibilities for others. Special encouragement and training may be needed for children who falter in making these adjustments and for those who may be headed for mental disability if precautions are not taken.

To assist teachers in the task of conserving mental health, they should receive special training in the mental hygiene of children and an appraisal

of the temperamental strengths and weaknesses of each child in the class should be furnished them. This appraisal can be made by competent specialists attached to the school staff.

Since parents play a pivotal rôle in child rearing, there should be arrangements for parent education in this regard. Such education can be valuable by giving parents an understanding of the human nature of children, by indicating their mental health needs and by assisting parents in their own adjustment.

If we restrict education to the imparting of factual knowledge and to training in special skills, we will continue to graduate many students ill-equipped to face the exigencies of life—many who will become victims of mental disorder.

Now, while childhood offers the best opportunity for preventive activities, much can be done with adults. To preserve mental health, adults need compelling objectives to give a sense of the worthwhileness to life. They need work that makes a pull on imagination and initiative. Adults require recreation, hobbies and avocations to furnish needed variety and change. And there is a place for intimacies, for the sharing of experiences with others, for a robust philosophy of life, for living in line with capacity, for the practice of relaxation, and so on.

There is no question, for example, that mental health is abetted if individuals learn how to relax. This is a difficult art in a world characterized by high speed and keen competition. We readily become the victims of tensions, and these, in turn, may lead to disorder. The individual who can work hard and then relax is in a position to guard both physical and mental health. This was illustrated by a coloured woman of 96 who enjoyed splendid health. She was in the habit of walking seven miles every day to her work and, when asked how she kept it, she said—"When I sits, I sits *loose* and sheds my troubles like an old garment." That is good advice for all of us.

The whole preventive field offers fascinating possibilities. And we can expect advance through the growing strength of the mental hygiene movement that is attracting the co-operation of scientists and the general public.

In conclusion, may I say one further word? Our most pressing need in connection with mental disorders is the development of more adequate arrangements for research. We have been attempting in Canada and other countries to fight these disabilities by bricks and mortar—by building more and more mental hospitals. We are spending ten million dollars annually in maintaining these institutions, but we are not spending half of this amount for research in discovering the nature of the conditions

we are attempting to treat. And, while we are slowly moving forward in the direction of control, we are not making the progress we should.

If 2% of public mental hospital expenditures were devoted to investigatory work, much could be achieved. We possess capable scientists in Canada eager to conduct research in this domain. Such centres as the University of Toronto and McGill University offer splendid facilities.

Mental disorders or Man's Last Spectre can be brought under control through attack by the scientist, and increased knowledge in this field will contribute to a better understanding of human nature generally—will contribute to the development of a finer civilization.

NORTH OF BATTLE HARBOUR

Alfred O. Gross

The lecture was illustrated with motion pictures taken on the Bowdoin-MacMillan Arctic Expedition to northern Labrador and the Button Islands.

The Button Islands, to the north of Labrador, were discovered by Sir Thomas Button. The strong polar current, tides, mist, and the ice pack made landing on these islands a matter of difficulty and danger. To this region the Bowdoin-MacMillan Expedition set out in 1934. The aim of the expedition was to make a biological survey. Commander MacMillan was especially interested in the anthropology of certain Indian tribes. Dr. Potter of Clark University was in charge of the botanical investigations. Parts of Labrador are peculiar from a botanical point of view as glaciers of the last ice age did not cover all the land. This left its mark on the distribution of certain plants which are now found in widely-separated localities that were not covered by glaciers. The lecturer's work in the expedition was the observation of bird life.

The trip was made up the coast of Nova Scotia and through the Gut of Canso. A short stop was made at Bird Rock, a part of the Magdalen Islands group. On the precipitous shore of this island gannets nest in great numbers. The razor-billed auk, murres and puffins live in close association on these bare rocks. Across the Gulf of St. Lawrence on the Canadian Labrador Coast both the common and double-crested cormorants were photographed.

On the way along the coast to Battle Harbour in Labrador no less than one hundred and fifty icebergs were seen. Along the rocky coast of Labrador the same individual puffins come to nest year after year. The puffin as seen in New England has a smaller and less brightly coloured bill. It has been observed that this bird moults its brightly coloured bill on leaving the nesting ground. Pictures of nesting murres were obtained. The eggs vary greatly in coloration and pattern, but the female murre will always lay eggs of the same colour and pattern of markings.

The Arctic tern breeds in Labrador in the summer but migrates to the Antarctic for the winter of the northern hemisphere. Strangely the migration route is through Europe. This has been interpreted as indicating that the original home of the Arctic tern was Europe.

On the Button Islands the snow is often red due to the presence of an alga. The main nesting ground of the horned lark is here although these birds do nest to a lesser degree, considerably farther south. The red-throated loon nests here near the water's edge. The adult bird never takes to the air from the nest but slides into the water and dives immediately, coming up some distance from the nest. The first motion pictures of the snow bunting were obtained here. Although the adults are seed eaters, the young are fed insects.

The excellent motion pictures of the birds of this region are a valuable contribution to natural history.

MEXICO

A. P. Coleman

One's first impression on entering Mexico from the north is that of a desert region of tablelands and bare mountains with little vegetation except plants of a very dry climate, especially cacti, the prickly pear and the organ cactus reaching the size of small trees and making prickly hedges around fields which are only green when irrigated. Going south toward the city of Mexico another plant of an arid climate becomes important, the *maguey* plant or agave, the familiar "century plant" of hothouse cultivation. This is cultivated on thousands of acres, since the juices of its flower stalk provides the favourite drink of Mexico, *pulque.*

My visits to Mexico have been mainly to study volcanoes. All the high peaks of the country are of volcanic origin and a few of them have been active within historic times. A visit to Colima in the western part of Mexico thirty years ago gave an opportunity to see very rugged recent lava streams and to reach the edge of the crater, filled with steam and giving off sulphurous gases.

Most of the volcanoes, however, seem to be extinct, and the higher ones are capped with snow and are, therefore, called *nevados* in Spanish. The Nevado de Toluca was ascended and its crater is occupied by a small lake at about 12,000 feet above sea level, one of the highest lakes in North America, though not so high as Lake Titicaca in South America.

The highest mountain in North America south of Alaska and the Yukon Territory is Mount Orizaba, near the city of the same name in Mexico. This reaches 18,200 feet, the last 2,500 feet being snow covered. This was climbed thirty years ago, after spending a night in a cave under a lava stream at 13,000 feet.

In a recent visit to Mexico the old volcano Ixtacihuatl, was examined for evidence of glacial conditions in the Pleistocene. The nearest town to this mountain, and also to Popocatepetl, the next highest peak in Mexico after Orizaba, is Amecmeca, which stands about 8,000 feet above the sea. From this town a ride on mule back took me to 14,600 feet, the last 1,500 feet being over morainic country, showing that a glacier had reached about 4,000 feet lower than the present small ice sheet on Ixtacihuatl.

Most of the travel away from railways or cities in Mexico is on horse

or mule back over rough mountain trails, though there are many motor cars in the larger cities, and the capital, Mexico City, at 7,500 feet, is a beautiful modern metropolis of over a million inhabitants.

Next in interest to the volcanoes and the great silver mines in the mountains of Mexico are the remains of the Aztecs, to be seen in the form of pyramids, temples and ruined cities in various places, suggesting a powerful, and in some respects, highly-civilized and artistic empire in existence before the Spaniard reached America.

The Pyramids of the Sun and Moon, not far from the city of Mexico, are astonishing monuments to have been constructed by a people without draft animals or mechanical appliances, and almost rival the famous pyramids of Egypt; and the buildings of Mitla, south of Oaxaca, display marvellous examples of ornamental stone work; while the jewels and gold ornaments of Monte Albano, to be seen in the Museum in Mexico City, indicate a highly-developed artistic ability and a surprising luxury of life in the higher classes of Aztec society long before Europe was aware that America existed.

So much of Mexico is tableland that most of the country has a temperate climate in spite of its being within the tropics; and it is very interesting to find a brown race, mainly of native American origin, building up anew a civilization overthrown by conquerors from Europe and taking pride in the monuments of its past greatness.

RECENT PROGRESS IN ASTRONOMICAL PHOTOGRAPHY

C. E. Kenneth Mees

Modern astronomical observation is carried out almost entirely by means of photography. The efficiency of such work is therefore dependent to a very large extent upon the quality of the photographic plates which are used and upon their suitability for the work to which they are applied. Photographic plates can be of many kinds, and the choice of the correct plate for each purpose requires, on the part of the user, a considerable amount of knowledge and a careful consideration of the plates available.

Photographic materials differ in speed, in contrast, and in colour sensitivity. These qualities are called their sensitometric characteristics. In addition they differ in two important physical properties—their resolving power and their graininess. To deal with each of these characteristics of a photographic emulsion would require too long a discussion, and the present report must be restricted to the great advances that have been made in the property of colour sensitivity and to some of the results that have been derived when these newest emulsions were applied to the photography of the spectra of the sun and the planets.

The spectrum of a luminous source provides the answers to many questions that the astronomer evokes in unravelling the physical nature of celestial objects. Out of the sequence of wave-lengths that is the spectrum of a star, certain discrete wave-lengths are eliminated through absorption by the gaseous outer layers, causing dark gaps in a continuum of colour. These absorptions, known as absorption lines, are as characteristic of a particular chemical element in a gaseous state, as is a fingerprint characteristic of a particular individual. The complex composition of the atmosphere of a star results in the appearance of a large number of absorption lines in its spectrum, not alone in the range of the spectrum embracing visible light, but in the invisible ultra-violet and infra-red regions. From these lines much is learned not only of chemical composition, but also of temperatures, of pressures, and of the abundances of elements. The study of many of the lines predicted to exist in the invisible regions is expected to yield important results, and the advance in the production of photographic emulsions sensitive to these spectral regions has opened new fields to the astrophysicist.

The photography by which the structure of the spectra of the stars

has been unravelled has been confined hitherto almost entirely to a limited region of the spectrum. The ordinary photographic plate cannot record light of longer wave-length than about 5,000 A., and thus the astronomer's range of the spectrum has, until recently, been confined to the spectral region between 3,000 A. and 5,000 A.

The introduction of panchromatic plates about thirty years ago resulted from the discovery of a number of cyanine dyes, derived from quinoline, that were excellent sensitizers. It was possible to photograph the whole of the visible spectrum up to a wave-length of 7,200 A. without difficulty, and panchromatic materials could be made that were sensitive through the whole of the visible spectrum in fairly even fashion.

It seemed as though we had reached a condition of perfection in our ability to photograph the visible spectrum, but in the last ten years we have realized that the possibilities of colour sensitizing dyes are far greater than we thought. Since 1925 very many cyanine dyes have been prepared, and photographic materials can now be sensitized for any part of the visible spectrum. Indeed, almost any position in the visible spectrum can be selected and a dye made to sensitize specifically with a maximum sensitivity at that point.

The scientist, however, has always wanted to photograph not only the visible spectrum but as far as possible into the infra-red region of the spectrum. Great success has attended the efforts made in this direction. Since 1919, at which time the limit of the spectrum which could be photographed easily at 7,200 A., dyes have been discovered which extend the limit as follows:

In 1919, Kryptocyanine (discovered at the Bureau of Chemistry in Washington), extension to 8,000 A.

In 1925, Neocyanine, to 9,000 A.

In 1932, Xenocyanine, to 11,000 A.

In 1934, Polycarbocyanine, to 13,000 A.

These new dyes have been of the greatest value to astronomers, who are now able to study the infra-red region of the spectrum, which it was out of the question to photograph in stellar spectra before the new materials were available. For example:—hydrogen in hot stars produces two well-known series of lines: the Balmer series in the visible and the ultra-violet is well known, but the Paschen series, that occupies the region between 8,200 A. and 8,800 A., has only recently been photographed.

Any views as to the possible nature of the surface of the planets must be influenced very much by a consideration of their atmospheres. There has been good reason to believe that Mars possesses an atmosphere. If there is any plant life on Mars, that atmosphere should presumably

contain oxygen, since any form of vegetable life would emit oxygen. Earlier measurements have suggested that there is oxygen in the atmosphere of Mars, but they were subject to the difficulty that there is a great deal of oxygen in the atmosphere of the earth.

If we photograph Mars at a time when it comes toward us and then again when it is going away from us, the lines which are due to the sun will be displaced in comparison with those due to our own atmosphere, and, if there are any lines due to the atmosphere of Mars, they will also be displaced. A suitable occasion arose a year or two ago for this measurement, and the results obtained led to the conclusion that the oxygen in the atmosphere of Mars is probably less than one-tenth of one per cent. of that in the earth's atmosphere.

When the spectrum of Venus was studied in the same way, a number of lines were found between 7,800 A. and 8,000 A. that were certainly due to the atmosphere of Venus, since they are not shown in the spectrum of the sun. These lines have been identified as being due to carbon dioxide gas.

The outer planets, Jupiter and Saturn, have similarly been shown to have atmospheres containing methane and ammonia and, since they are very cold, we may depict them as having masses of solid ammonia floating on a sea of liquid methane.

While the study of the atmosphere of our nearest neighbours in space is most fascinating, the investigation of the nature of distant stars and the even more distant nebulae is of even greater importance.

Advance in this work is dependent on the collaboration of three different branches of science, all of them employed finally by the skilled astronomer, whose results must be analyzed by the mathematician. The optician is making great strides in the development of new telescopes and new spectroscopes; the chemist is making for us the new sensitizing compounds derived from ever more complex organic bases; the photographer must make improved emulsions and apply to them the sensitizing dyes, so that he can place in the hands of the astronomer photographic material worthy of the instruments and the skill which the astronomer employs. Fortunately, we are all working in harmony and, as the results show, we are making progress. And to make progress in studying the ordinances of Heaven and the foundations of the earth is one of the greatest privileges given to man, that he should be allowed to be present when the morning stars sing together and all the sons of God shout for joy.

PROCEEDINGS

of the

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FOREWORD

In the first place, an apology is due the reader for a mistake that crept into the previous volume of this series. It was designated as Series III, Volume I, but as there is, in the publications of the Institute, a previous Series III which was published from 1879 to 1890, this was obviously a mistake. To differentiate this series from the previous Series III, it is now designated as Series III A and this correction should be made on copies of Volume I of the series issued last year.

As in the volume of proceedings published in 1936, it has not been possible to print all addresses delivered before the Royal Canadian Institute during the season 1936-37 in extenso. Where this has not been possible, either full resumés or short summaries are given, except in the case of two lectures which have appeared or are appearing elsewhere. Dr. W. F. G. Swann's lecture on "Science and Common Sense" has, in substance, appeared as Chapter IV of The Story of Human Error, edited by Joseph Jastrow, published by D. Appleton-Century Co., New York and London; while Professor (now Sir) D'Arcy Thompson's lecture on "Science and the Classics" is to appear in the Proceedings of the Classical Association, London, England.

CONTENTS

THE MINING INDUSTRY IN ONTARIO

HON. PAUL LEDUC

Gold has always been a chief object of human desire. This shining and intriguing metal has played, since time immemorial, a leading part in the history of mankind. The oldest records mention gold as a very precious substance, and there is tangible evidence that the ancients had recognized the value of the yellow metal. The unsealing of Tut-ank-amen's tomb revealed to the eyes of astonished scientists adornments of pure gold as brilliant and attractive as they had been, thousands of years ago, when the great King's mummy was laid to rest. This gold came, either from the placer fields of Nubia, or from the lodes in the regions seated between the Nile and the Red Sea. It is known that the ancient Egyptians also mined gold in Arabia centuries before Christopher Columbus, in the hope of replenishing the empty coffers of Spain, set out towards the West in search of treasure

Columbus was haunted by the phantom of gold which he pursued relentlessly from island to island. He had read of a city in far off Cathay where even the shingles of the houses were made of solid gold. He had heard also of a fabulous island containing seven cities where gold was to be found in abundance, and for a while he thought that he had found that island in Cuba. Unfortunately, after each one of his trips he was forced to go back to Spain without much of the precious metal.

However, his success in finding new lands prompted the adventurers of Spain to set sail for the West, also in the hope of finding other lands and richer treasures. The kings of the Christian world outfitted expedition after expedition. The need and the desire for gold, silver, precious stones, spices and furs, which were reported to exist in fabulous quantities, were the main reasons behind the great explorations of the 15th and 16th centuries and not, as has been commonly believed, a desire to colonize new lands and to spread the word of God therein.

The Spaniards to the South were luckier than their French and English rivals to the North. They found gold and silver. Their ships returned richly laden, sometimes to fill the coffers of their kings and sometimes to be waylaid and captured by pirates or

adventurers from other nations. The French explorers were not so successful. Jacques Cartier found furs in Canada but very little gold. It is reported by Lagarto, a Portugese spy at the court of Francis the First of France, that, in an interview he had with the King, the latter related to him that he had sent twice to a river in the land of God which was marked out on some charts in the King's possession, and that the leader of his expedition had, on his last voyage, brought back three Indians. Then, Largarto goes on to say: "And thus he, the King, told me that the river he sent to discover he has heard is 800 leagues long, and while up the river there are two falls, and beyond the falls the King of France says the Indian King told him there is a large city called Sagana where there are many mines of gold and silver in great abundance, and men who dress and wear shoes like we do and that there is an abundance of clove, nutmeg and pepper . . . . . And the said Jacques Cartier brought to the King a sample of gold, ten or twelve stones shaped like small goose quills, and he said it is fine gold and comes from the City of Sagana, and he believed that by this river would be found a passage to the other southern ocean, but he now knows that there is none."

In Cartier's relations, he relates that the Indians pointed to a dagger handle of yellow copper-gilt like gold that hung at the side of one of the sailors, and gave the French to understand that these came from up the river. Biggar interprets this to mean that the Indians knew that gold existed up the Ottawa River but in the original French Cartier used the expression 'fleuve' which evidently refers to the St. Lawrence. It would look, therefore, as if the first gold brought to Europe from Canada came from somewhere in Southern Ontario. In any event, these small gold samples were all the gold that Cartier ever saw or brought to his King's attention.

When Samuel de Champlain, the first governor of New France, came to Canada, he was accompanied by one Prevort, who passed much of his time investigating the mineral possibilities of the new country. In his records, Champlain alludes to the discoveries of Prevort. He was so much impressed by the showings of copper and "silver" that, on his second trip to New France, he brought with him a mining engineer, Master Simon, so that a closer check could be made of Prevort's discoveries. Simon confirmed the presence of minerals but no effort was made to operate any of the ore bodies. However, the interest of the Court had been aroused and, in 1653, Louis the Fourteenth granted Sieur Nicholas Denis a patent to

explore for minerals in New France. His expedition constitutes the first full time attempt to investigate minerals on the American continent. To Denis belongs the credit of the discovery of the great coal beds of Cape Breton. This took place in 1672 and five years afterwards Mr. Duchesneau, then Intendant of New France, proclaimed the imposition of a royalty of 20 sous per ton on coal mined in Cape Breton. I believe that this is the first instance of a mining tax in Canada.

Under Intendant Talon the search for minerals was vigorously pursued and so it was that bog iron was discovered near Three Rivers and the first metallurgical works in Canada ware launched on the St. Maurice River by the Compagnie des Forges, in 1737. The state of war, under which the young country had been living, delayed the search for and development of its minerals. Peace and its stabilizing effect finally resulted in a definite step forward and the mineral industry of Canada was born.

From the dawn of the nineteenth century, many deposits of iron were worked in Ontario, foundries were installed and a rushing business was done for a while. It was not, however, until 1866 that the vast possibilities of our province were recognized. At that time, Marcus Powell discovered free gold on the farm of J. Richardson near Madoc, in Hastings County. It was the 15th of August and Powell, along with a man named Berryman, was tracing up a vein of copper. At a depth of about 15 feet the vein matter became somewhat decomposed and carried native gold. Powell feverishly tore his way through six feet of this matter and through fifteen feet of solid rock. Then he suddenly broke through what he called a cave literally covered with gold in the form of leaves and nuggets. Some of these nuggets, it is reported, were the size of butternuts. The news of this discovery travelled like wildfire and in no time a genuine gold rush was taking place. Four horse stage coaches carried the would-be prospectors from Belleville to the village of Eldorado.

To this day, no one has ever found out the amount of gold extracted from this remarkable find. It is recorded that the Richardson Mine, so it was called, was finally sold to Chicago interests for $36,000. Singularly, the original gold find of Ontario has never been duplicated for its unique geological features. It never was a commercial success but resulted in stimulating prospecting in eastern Ontario, which culminated in the successful operation of a dozen gold mines in that district, the forerunners of one of the greatest industries in the whole of Canada.

At the time of the Madoc gold discovery, some considerable activity was taking place in the Thunder Bay district on Lake Superior. Silver had been found and workings were numerous. But the richest and by far the most important of these was the one on Silver Islet, a tiny rock 90 feet by 90 feet, off Thunder Cape. Thomas MacFarlane found silver and galena on the surface. A mine was opened up and work carried on under great difficulties. Water, ice and wind were continually causing damage and impeding the work of the miners. The operations were continued notwithstanding the oft-repeated attacks of wind and waves, and mining was carried on with some intermissions until 1884. Of all things, the over-indulgence in whisky of a boat captain was the cause of the end of operations on the rich property. The captain failed to arrive with a cargo of coal before the close of navigation, and coal was required to operate the pumps that kept the workings free from water. The shipment having failed to arrive, the underground stopes and levels were filled with the seepings of Lake Superior, and it was the end of silver mining in that area. Silver Islet, in about 16 years, had produced something like three and a half million dollars of silver.

A number of other mines were operated from time to time on the north shore of Lake Superior until 1903, but, in the meantime, other metals and minerals were being brought to attention as discovery followed discovery.

The Government at Ottawa had not been deaf or blind to what was going on. In an effort to ascertain the character of rocks in what then fell under the boundaries of Canada, a geological survey had been instituted in 1843 under Sir William Logan, the discoverer of the great Pennsylvania coal fields. This was to prove a considerable boon to prospectors.

Oil was found in Lambton county, salt was produced for the first time in Ontario near Maitland River and Eastern Ontario was shipping hundreds of thousands of tons of iron ore to the United States.

But there was still another surprise in store for Ontario, and it all began in 1883 with the discovery of the copper-nickel ores near Sudbury. Strange as it may seem, four years elapsed before nickel was identified with the copper ores. It was thought at first that the deposits were composed solely of copper, but a shipment of a quantity of ore to Bayonne, New Jersey, proved refractory in the furnace. On assaying the ore, a chemist detected nickel, so called by the old German copper miners, whose ores sometimes behaved in like manner, after "Old Nick," the author of all evil. The realiza-

tion that the Sudbury basin contained this metal caused a transformation in the industrial aspects of that region. Many were those who had staked properties in the "Nickel Range," that oyster-shaped basin, thirty-six miles in length and sixteen miles wide. The claim holders realised that their properties were underlain by rich copper-nickel deposits. Nickel was worth many times the price of copper. An intensive exploration and development followed. At about the same time, a Scotch engineer by the name of Riley gave to the world a remarkable alloy. He added a small proportion of nickel to steel and made this useful commodity even harder and more resistant than it had been. The American Navy first utilized this latest development in the field of metallurgy in the production of armour plates.

In the course of tests, the armour plates proved to offer greater resistance to shells than ordinary steel, and it was thought for a short while that a way had been found to make defence superior to attack. Then, of course, someone thought of using the new alloy for shells and the armament race once more went merrily on.

To-day, nickel is applied to a thousand and one uses, and it is gratifying to know that over 80% of a metal which was formally thought fit only for war purposes is now used for domestic and other peaceful purposes. An idea of the vastness of the Sudbury operations can be formed from the amount of money paid out in wages and salaries. In 1934, nickel-copper mines employed 5,793 men and paid them $8,600,000. In 1935, the number of wage-earners jumped to 7,194 with a pay roll of 11 millions. These figures will be appreciably increased for the present year as a building and extension program, costing many millions of dollars, and a campaign to bolster up the production were instituted some months ago.

The presence of platinum and platinoid metals in the Sudbury ores is an interesting feature of that vast mineral storehouse. The Sudbury companies not only lead all the rest of the world in the production of nickel but also enjoy the distinction of undisputed leadership in platinum production. Much gold and silver are extracted from the complex ores, so that it can be said without fear of contradiction that the Sudbury basin is one of the most remarkable mineral deposits ever developed by man.

Half a century had passed since Thomas MacFarlane made his silver discovery on Silver Islet. The construction of the T. & N. O. Railway was being proceeded with in Northern Ontario. In 1903, two timber cruisers were attracted by shiny nuggets some four

miles west of Lake Temiskaming. They picked them up and sent them to Montreal for assay. Following the report that these nuggets were native silver, a few weeks afterwards a blacksmith, named LaRose, working on a construction gang along the T. & N. O. Railway, came across a small outcropping of a mineral which he thought was copper. Professor Miller, then Provincial Geologist, visited the scene of the discovery and noted the presence of nickel but found that there were valuable deposits of silver in the district. Other prospectors by that time had located other veins, had done some surface stripping on two of them, and had taken from the shallow trenches heavy lumps and blades of a mineral which Miller identified as silver.

Strangely enough, it was not until 1905 and 1906 that a real rush set in. Many new veins and stringers were found. These veins were usually narrow and shallow but extremely rich. The town of Cobalt, so named by Professor Miller, was built in the very heart of the mining camp. After enjoying many years of prosperity, the low price of silver and the spectacular gold discoveries in the Porcupine field to the North, brought this once intense field of action to a relative standstill. This, for the time being, was the end of Cobalt as a great mining camp.

A pecularity of the history of mining in our province manifests itself in the rule that one discovery leads to another. We have seen, as a result of the Madoc discovery, several mines opening up in Eastern Ontario. Later on, the exploration of the Thunder Bay district brought about the finding of silver on the mainland and then a veritable bonanza on Silver Islet. Cobalt was no exception to the rule. The intensive interest built up by nature's lavishness in this case and the fact that all the favourable ground had been taken up caused the prospectors to turn their eyes to the north and the west.

Jack Wilson and a party of prospectors set out from Haileybury in the spring of 1909 and arrived at the Porcupine River, in the neighbourhood of which E. M. Burwash and W. A. Parks, Government Geologists, in the late nineties, had reported indications and small showings of gold. Parks had even incorporated the following prophetic statement in his report: "I regard the region south of the trail to Porcupine lake as giving promise of reward to the prospector." Wilson and his party were there to claim that reward. They found it in a vein of quartz 21 feet wide and in a large mound of the same material splashed with free gold from bottom to top. It can be said that, as a gold producer, Ontario stepped into fame on

a golden stairway, as such a colourful designation was given to the dome of white quartz on what is now the Dome Mines. Part of the dome, or "golden stairway" now rests in the corridors of the Parliament Buildings along with other interesting mineral specimens in the Government's collection.

It was W. S. Edwards of Chicago who had commissioned Jack Wilson to organize a party to prospect the Porcupine country. It may be that Edwards had read Dr. Park's report. At any rate, his men certainly met with success. Two of them, George Bannerman and John Geddes, staked a claim in Whitney township on which was afterwards developed the Scottish-Ontario Mine. The recording of that claim along with the sensational richness of the "Golden Stairway" led to a wild rush from the farms and villages along the railway to be followed by legions of gold-hungry men from all parts of the country and outside points. The bush suddenly was alive with prospectors eager to share in the "reward" promised in the geologist's report. To the end of 1935, the Dome property has yielded over 75 millions of dollars in new wealth.

Foremost in the rush that followed the striking discoveries were Benny Hollinger, Alex. Gillies, Sandy McIntyre and John Miller. Fate was unkind to the discoverers of what has proven to be Canada's largest producing gold camp. Not one of the finders of its riches participated in any substantial way in the flow of gold which has streamed out of the properties. Those who came after them garnered the profits.

Perhaps the most heart-breaking of them all is the sad story of Reuben D'Aigle, a descendant of New Brunswick Acadians. D'Aigle, who had been prospecting in the Yukon for a number of years and had come back with some gold, chose the Porcupine district as a field for further explorations. In 1907, he had started North and by easy stages finally had reached Whitney and Tisdale Townships. He staked seven claims but panning showed no gold. He pocketed a few samples and prospected other parts of the field but, meeting with no success, he returned to Toronto where his samples showed very low-grade values. He returned to the field the following spring with a party of six men. A short distance south of the big quartz dome that he had discovered during the previous year, he sank a test pit but was unable to find any gold. This discouraged him and D'Aigle finally dropped his undertaking and went to Gowganda to look for silver. It just happened that not many feet from his trench the moss on the quartz dome hid from

view millions in gold. However, D'Aigle by abandoning the scene had waived all his rights to fame and fortune as the discoverer of the Hollinger mine.

Benny Hollinger, a young man not yet in his twenties, and his partner, Alex. Gillies, two experienced prospectors who had worked together for two seasons, but without any luck, were about to break up their partnership when the news came of the Dome strike. They were itching to go but did not possess sufficient means to carry out another expedition. They tramped the streets of Haileybury in search of a grub staker. Each sought out a separate backer. Jack McMahon gave Hollinger $45.00 while Gillies received a $100 bill from Jack Miller. The two gold seekers were working together but for two different men. These details I mention as they have an important bearing on what is to follow.

The two men arrived at Porcupine Lake on October 3, 1909. Most of their camp stuff was left at the lake side and, with two days grub in their rucksacks, they took to an old Indian trail which led them along Pearl lake toward the Mattagami River, the same trail that had been part of the itinerary of the voyageurs of the North for more than 200 years.

Hollinger and Gillies prospected the shore of the lake and came upon a vein which showed no free gold. They roasted some samples in the fire and hammered them up with an axe. The crushed ore was then washed and revealed gold tailings two inches long. They staked out their first claim the very next day and continued their search, staking as they went along. To the west of the lake they came upon the abandoned workings of D'Aigle. They saw a shallow pit, and, rusting nearby, the remains of an old forge and anvil. The next day Hollinger struck gold. Free gold seemed to be everywhere, and, as the moss was torn from the Dome of rock, the shining metal appeared. Even the floor of the abandoned test-pit yielded over $50.00 to the ton through channel sampling. The two men, in high spirits, staked twelve adjoining claims between them But the real problem now confronting them was the apportionment of their claims as they had been grubstaked by different parties. Of all things—one cannot prevent smiling at the thought of it—the division of the claims was decided by the toss of a coin. Hollinger won and took the first or the east group of six claims. On their way to the recording office, they met Sandy McIntyre, Jack Miller and another prospector. They told them of their luck and continued on their way. At Haileybury they told their story to Alphonse

Pare, a young mining engineer and nephew of Noah Timmins, who acted as scout for the Timmins interests. He lost no time visiting the property and advising his employers to buy it at all costs. The Timmins-McArthur-Dunlap syndicate, which had reaped a fortune in Cobalt, bought Hollinger's original six claims for $330,000 and later took up options on adjoining claims.

By this time, McIntyre and Miller, who had rushed to the scene of activities, had staked out their own claims. McIntyre got rid of his claims for a song.

That so much wealth should be discovered by less than a half-dozen men in the space of a few days, is a fact which stands out in the history of mining in Ontario. It was a fortunate thing for the Porcupine camp that the Hollinger property passed so early into the hands of a group of men who had already made a fortune in Cobalt. The syndicate was comprised of Noah Timmins and his brother Henry, Duncan McArthur and his cousin John A. McArthur, railway contractors from Cornwall, and a lawyer and fellow townsman of the Timmins, David A. Dunlap from Mattawa. These men took no small part in the development of the mining industry, not only in Ontario but throughout Canada. Now they have all gone. The death of Noah Timmins, on the 23rd of January last, has removed the lone surviver of the original syndicate.

Such were the beginnings of the Porcupine Camp which has, for the last twenty-five years, produced over $425,000,000 of gold. There are now seven producing mines in that district, and it is slowly extending to the east and, it is hoped, also to the west. The older mines, which have been worked for about a quarter of a century, show as yet no sign of exhaustion.

A large community has grown around the mines. Timmins, named after the late President of the Hollinger Mine, is now a thriving city of nearly 20,000 people. It is just as quiet and orderly as any town of its size in the southern part of the Province. About 5,000 men are employed by the mines in the camp. They earn, on an average, more than the skilled labourers of Southern Ontario. If their daily wages are not quite as high, they suffer no periods of unemployment. The work of the mines goes on without interruption from the 1st of January to the last of the year, and the fact that there have been no strikes in the mines for a great number of years tends to prove that the miners are generally satisfied with the treatment they receive from the mines.

As in the case of Porcupine, the discovery of the second largest gold camp in Canada was directly attributable to the prospectors of Cobalt. Unlike the Porcupine field, the Kirkland Lake Camp came into being quietly. The world had been astonished by the former and it did not seem possible that there could be another Porcupine in Ontario. This at least was the general view, but luckily it was not shared by a few determined prospectors who dropped off a T. & N. O. train at Swastika in the summer of 1911, attracted to this jumping-off place, no doubt, by a not inconsiderable activity at this very station.

W. H. Wright and his brother-in-law, Ed. Hargreaves, started out in July, by canoe, for Kirkland Lake. They had heard that much staking had taken place in that district. As a matter of fact, the Burrows brothers had staked what is known today as the Toburn Gold Mines as early as 1906. Wright and Hargreaves began prospecting on the first open ground encountered. On the third evening, at sunset, Wright found free gold and the two men staked four claims. Wright held on to a quarter interest in this property and is to-day a multi-millionarie.

Strange to say even Wright's rich strike did not attract the attention expected and it was not until a year and a half later that Kirkland Lake stepped definitely into the limelight.

At the end of January, 1912, the Tough brothers met Harry Oakes, a prospector of much experience, who had seen a lot but had earned very little. They talked about mining and allied subjects. Tom Tough finally said he would like to stake some claims near the Wright find. Oakes, who had no money, told him he knew of some claims that would fall open for staking and that he was prepared to share with a partner who had the funds required to pay the recording fees. Oakes added that these claims would be open for restaking that very night at midnight. An agreement was reached between the men and at 4.00 o'clock in the morning the next day the prospectors set out from Swastika on the six-mile trek towards the east. They reached the property just before dawn. The men set to work immediately staking claims. As the last stake was being driven into the ground, W. H. Wright came upon the scene. Not to be outdone, he staked the adjoining claims.

Three days after the staking of the Tough-Oakes claims, George Tough found free gold in a rich quartz vein. In the meanwhile, Oakes and Wright had staked water lots on the south shore of Kirkland Lake. The news of George Tough's discovery of free

gold brought a contingent of prospectors and engineers rushing to the scene. Oakes bought claims adjoining his newly staked property and then formed the Lake Shore Mines.

Unlike the great majority of prospectors, Oakes did not part with his claims. His fight to organize and finance his property for development purposes was a hard and bitter one. He raised money through the sale of shares at fifteen cents, and realized an amount sufficient to bring the mine into production in 1918. Lake Shore has paid dividends every year since the beginning, and to this day has produced nearly $100,000,000 of gold. Last year it ranked as the eighth greatest producer of the world.

The Camp of Kirkland Lake now has eight producing mines and, from 1913 to the end of last June, has produced ore from which nearly a quarter of a billion dollars worth of gold has been extracted.

The favourable development of Porcupine and Kirkland Lake was especially interesting as it came after a long record of disappointment in connection with gold mining in Ontario.

Cobalt had produced hundreds of able prospectors, men who knew the geology of Ontario, men who had faith in its possibilities. With each successive discovery their numbers grew, and their technical knowledge of rocks along with their practical experience have earned for them the title of the best prospectors in the world.

With Porcupine and Kirkland Lake fresh in their minds the prospectors in scattered groups took up the search for favourable host rocks in far-flung fields. Many discoveries have been made in recent years but for the greater part their possibilities have yet to be proven by further development.

Gold was first discovered at Red Lake in the summer of 1897 by a party headed by R. J. Gilbert. Unfortunately, Gilbert was killed by the accidental discharge of his revolver, and the secret of the gold discovery that he had made was forgotten. In 1912, a young mining graduate of Queen's University, took some samples near the present site of the Howey Gold Mines. Again this expedition met with misfortune. The canoe containing the samples and all the provisions was swamped. Davis lost heart and did not go back for other samples. However, other prospectors visited the region, and, in 1924, Dr. L. Bruce, of the Ontario Department of Mines, was sent to Red Lake to report on the geology of the area.

A year later, in 1925, Lorne Howey found free gold near the shore of Red Lake. His brother also made another find not far away from the first discovery. They lost no time in staking what turned

out to be the first commercial gold discovery in the Patricia district. The usual rush of prospectors followed the recording of these claims. It was a long trek from steel into this new area. A canoe was the only mode of transportation in those days and it took several days to reach a camp which is now so easily accessible by airplane.

Gold was there but investors had to be convinced that it would be worth their while to back the development of the claims with their money. Howey got in touch with Jack Hammell who agreed to look the property over, and finally agreed to purchase the claims and to spend $50,000 on the development. He formed the Howey Gold Mines Syndicate, took over half the units, and gave the remaining half to the stakers.

It was very late in the season and, as usual, Jack Hammell wanted action and he wanted it at once. He prevailed upon the Gevernment to press its Forestry planes into service. It was, perhaps, the first time that airplanes had been used in mining development, and in a short time the required supplies were landed at the scene of operations.

The story of Howey financing and development is a long one. Finally, the mine came into production in the winter of 1932 and has been producing ever since. Under the efficient management of Fraser D. Reid, Howey enjoys extraordinary low costs of operations, and is able to mine at a profit ore that contains less than $3.00 in gold to the ton.

In the same district are now two other producing mines—McKenzie Red Lake and Red Lake Gold Shore. There is a thriving community of some 2,000 people near the Howey Mine and the citizens of Red Lake will have no hesitation in telling you at any time that their camp is only at its beginning, and that several new mines will join the three existing ones within a short time.

To the East and North of Red Lake are Woman Lake and Trout Lake where several companies are actively operating, and further to the East again are the Pickle Crow and Central Patricia Gold Mines.

Central Patricia has been in operation for about 2½ years, and Pickle Crow for about a year and a half. So far these two mines are the only producing ones in that district. It is hoped, however, that others will eventually reach the production stage.

Some twenty years ago, Tony Oklend, a woodsman and trapper, found some gold on the shore of the lake. He had chiselled the metal out of a boulder and sold the proceeds to the Hudson Bay

Post at Long Lac. Years after, in September, 1913, a veteran prospector, Tom Johnson, arrived in the district and made several discoveries which he staked. He met Oklend in June, 1932, and the two men worked together. Oklend, who had had time to observe the geology of the area, pointed out that he knew of several places where they might find gold. It was on July 5, 1932, that Johnson made a spectacular find in the shallow water of the Lake near the shore. The samples were so rich that no effort was required to find a buyer. The Sudbury Diamond Drilling Company offered $2,000 cash to the prospectors along with a 10% interest in the mine, an offer which was quickly accepted by the two partners. Such was the beginning of Little Long Lac Gold Mines.

A wild rush of staking followed this discovery and hundreds of claims were recorded. Properties such as the MacLeod-Cockshutt, Hard Rock, and many others on which spectacular finds were reported this summer, are situated a few miles away from the original discovery.

The increase in the price of gold from $20.63 to around $35.00 has had the result of re-opening several mines which had been abandond because the grade of the ore was too low to be treated at a profit. This increase has resulted in the resurrection of mines as well in Northwestern Ontario as in the Lake of the Woods area. There has been a great deal of activity this last summer around Kenora and Sioux Lookout. There has also been a renewal of interest in mining in the old counties of Frontenac and Hastings. It is, as yet, too early to say what will be the results of the late summer's gold rush, north of Arden and Northbrook, but it is significant that several important companies or syndicates have thought it worth their while to investigate conditions there.

The prospectors are forever looking for new regions where to find gold. The latest discovery in Ontario has been on the Sachigo River, a few miles from the Manitoba boundary. Recent discoveries include those at Mink Lake and Favourable Lake

I do not claim to have given you a complete list of all the areas of Ontario where gold has been found in more or less abundant quantities. I have merely touched upon the most important parts and some of the newer regions, and, because time presses, I will content myself with a passing reference to the Chromium Mines at Obonga Lake which started operations about a year ago. I believe that what I have said is sufficient to indicate the extent of mining operations in our Province.

The Government of the Province has, for a number of years, taken a great deal of interest in the mining industry. Ths interest has been intensified on account of the ever-increasing need for new sources of employment for the people of Ontario. The gold mines of the Province, that employed 10,193 wage earners in 1934, at an average salary of $1,491.00, employed 11,132 in 1935 at an average salary of $1,602.00. Complete statistics are not yet available for the current year, but we know that this number will increase again with a corresponding rise in wages paid. As a matter of fact, this industry has proven one of the strongest factors in maintaining the financial integrity of Canada during the past five years.

Owing to the isolated location of the industry in which they find employment, the men, as well as the mines, are dependent almost entirely on outside sources for everything they buy.

During 1935, gold mining alone accounted for $76,000,000 of new wealth. We fully expect that in 1936 the total will be brought up to a little over $79,000,000. These figures, of course, do not include the gold produced by the nickel-copper companies which will this year have a value of approximately $2,200,000. We expect the production of all metal mines to reach a total of not less than $170,000,000 including gold, nickel, copper, platinum and allied metals, silver, etc.

What becomes of this large amount of money? Some of it, probably from 30 to 35 million dollars, is paid in wages. Then large sums are distributed in dividends. These, of course, may be paid to shareholders residing outside of Canada, and, as a matter of fact, we all know that there is a very large amount of British and Foreign capital invested in our mines. The rest of the money will be disbursed in various ways. Supplies have to be purchased for the mines and these supplies have to be brought to them. Railway companies, aerial transportation companies, trucks, tractors, scows and tugs are pressed into service to carry thousands of tons of coal and steel, millions of feet of lumber, mountains of sand and gravel, quantities of explosives sufficient for a small war, and the other thousand and one things that the mines require each year. If the property is in a remote section of the country and difficult of access, the management will take advantage of the favourable season to freight into the mine vast reserves of all it needs. The store-rooms of certain of these mines contain enough supplies to stock a large-sized store and keep it going for months.

One mine alone in 1935 paid a freight bill of over $3,000,000. Its

lumber requirements amounted to something like 4,000,000 feet a month, and kept 800 men busy in the bush and in the mill. Of course, lumber and some other articles come from Northern Ontario, but by far the greater part of other supplies comes from the Southern part of our Province. Millions are paid every year by Northern mines to Southern firms that manufacture steel, tools, electrical appliances, Diesel engines, mining machinery, explosives and whatnot. In the newer districts, where they have to feed their employees, they also import huge quantities of food supplies of all kinds. Some of the mines also own their own airplanes and these also come from the South, and many trucks and tractors of Southern make are also used on the mining roads of the North country.

Then there is a tremendous power bill that the mines have to pay each year. The Hydro Electric Power Commission and one or two private companies collect huge amounts from the mines and, in turn, spend a large part of their receipts in the South, where they secure all the machinery and equipment required by their power plants.

In such ways is spent a very large part of the $175,000,000 produced by our mines, and the employees and wage earners in turn pour into the South a never-ending stream of money. These men, as I said before, are well paid. They live as well as, if not better than, their cousins of Southern Ontario. They need food, of which the North as yet produces but little. They need clothes, shoes, furniture, gramophones and radios, bicycles and motor cars. They smoke tobacco and some times will take a glass of beer or of some other beverage provided by our Ontario Liquor Control Board. Their wives and daughters are not averse to the use of lipstick and other toilet accessories. They also need clothes and want to be as well dressed as their sisters from the South. I daresay that they consume as many chocolates as their cousins from Toronto, and of course, all these necessaries of life have to be imported from our part of the Province. The farmers and the gardeners, the manufacturers and the working men of Southern Ontario have a vast and ever-expanding market North of the French River and their prosperity depends to a great extent on the continued existence of the mines.

It is rather difficult to make an estimate of the number of men who are kept working in the Southern part of the Province to provide for the needs of the miners, but I believe one would be safe in assuming that every man who works in a Northern Ontario

mine supports at least another man in the Southern part of the Province.

I have mentioned airplanes once or twice. No one can over-estimate the services rendered to the industry by aviation. Planes have made accessible areas that were formerly days and weeks away from civilization. A number of companies operate regular services into some of our northernmost mining camps, and it is not an exaggeration to say that there are continually several planes in the air, swiftly carrying passengers, mail and freight between Hudson and Sioux Lookout and the mining camps of the North. Air transportation made it possible for the Department to send prospecting parties into the Sachigo and Mink Lake areas last summer, and the members of these parties reached their destination in a few hours from the air base. Fifteen years ago it would have taken them weeks to get to these distant gold fields. Airplanes have been used, time and time again, to rush to the hospital some sick or wounded miner, or even an expectant mother, and one cannot count the number of lives that were saved. Mining has done more than any other single industry to help in the development of our flying, and this is not one of the least important services that it has rendered to our country.

Most of the mines take some interest in the welfare of their employees. Of course, a great many of them, especially in the newer districts, have to build bunk houses and other buildings to house them, but, in the older camps, many of the mines have built houses that their employees can get at a very low rent. Others have provided skating rinks, community halls, hospitals, schools and even churches when the welfare of their employees and their families demanded it. I know of at least one mine that, in addition to hot and cold showers for employees coming from underground, has provided batteries of sun lamps to give them a sun bath before they again get dressed for the street. I know, also, of at least one mine that maintains at its own expense a laboratory where experiments are conducted to find the cause of silicosis and the possible remedy for this dread disease.

The mines not only are providing all these services for the miners, but every large mine now has a safety department, the sole concern of which is to provide greater safety for the workers. These organizations have succeeded in materially reducing the number of accidents in the mines of this Province. We have reached the point where the ratio of fatal and non-fatal accidents in Ontario

is lower than in the metal mines of the United States or of the other Provinces. The latest statistics which I was able to obtain for the United States show that, in 1932, 53,288 men were employed in metal mining in the United States, and that year the number of fatal accidents was 107, or two per thousand of the men employed. In Ontario during the year 1935, the number of employees in and about metal mines was 22,072, and the number of fatal accidents 35, or 1.52 per thousand men. Our rate is also lower than in British Columbia or Quebec. I might also point out that, whilst in 1935 we had 35 fatal accidents, the number in 1911, 25 years ago, was 49 with a much smaller number of men employed in the industry.

It is, of course, the wish of everyone that the number of accidents be reduced. It is impossible to expect that none will occur in any given year when 22,000 men are working under hazardous conditions, but I, for one, do believe that the mines, if only for their own selfish purposes, are interested in seeing the number of accidents decrease every year, and are doing all they can to achieve that end. I might point out that, as a result of safety work done in one of our large gold mines employing thousands of men, there was one month this year where not one of the employees had to go to the hospital to be treated for an accident, and in another month the total of days spent in the hospital was one.

The Government of the Province also is intensely interested in the safety of the miners. We have, in our Mining Act, a set of regulations drawn up with that very purpose in view, and in each of the three main mining camps is an Inspector of the Department whose main duty is to see that these regulations are enforced. We also have another Inspector who is in charge of all mines west of the Michipicoten area and there is, in addition to the Chief Inspector of Mines, a sixth official whose duty it is to inspect all electrical machines and appliances used by the mines. The Department has a machine to test steep ropes used by the mines. I was rather flattered to find out, in a recent trip to the mining regions of Quebec, that the ropes used by Quebec mines are also tested in my own Department at Toronto.

The Government derives substantial benefits from the operation of metal mines. Every new mine provides employment for a certain number of men and, of course, unemployment is at present our main concern. Realizing the importance of this industry in the economic life of Ontario, the Government has not hesitated to agree to stabilize the profits tax on mines for a period of several

years and, at the same time, we have extended the services provided by the Department to help the mining industry. We have more Geological Survey parties in the field this year than ever before and we have more than doubled the Prospector's Classes which are given in mining regions and in the main cities of Southern Ontario to help the would-be prospectors and generally those who are interested in prospecting.

The policy of the Department has been, for a great many years, not to hinder the prospectors or the miners but to help them, and we are always on the lookout for new ways to extend that help to them. This year, owing to the co-operation extended by the Dominion Government, a rather extensive road building programme was started in order to help transportation into new mines. The Dominion Government and the Province of Ontario are spending over half a million dollars in our Province on some 24 or 25 different projects, and I have already been assured by officials of several of the mines concerned that our contribution has been of great help to them. We hope that the Dominion Government will repeat its gesture next year and the years following, and that we will be able, from year to year, to give the mines all the help they require by way of transportation. We are not worried so much with the old mines which are well established and are paying generous returns to their shareholders. Our concern is with the new ones which are just starting, and whose finances do not allow them to do the work which the old ones can do.

I have tried to give you, as briefly as possible, the history of mining in Ontario and to show how it spread from one camp to another during the last half century, and more so within the last thirty years. I have also tried to make you realize the importance of mining in the economic life of this Province. We can be justly proud of this great industry, but, at the same time, we should be thankful to Providence which has given us the metals that contribute so much to our prosperity. We have been for many years, and still are, the premier mining Province of the Dominion. We will keep in the front rank for a long time but we must admit the fact that in recent years other provinces, especially the Province of Quebec, have discovered new mining areas, that several new mines are now providing gold in large quantities, and that the copper production of Manitoba and Quebec is steadily increasing.

I am not jealous of the progress made by our neighbours. As long as our own mines are prosperous, as long as they give employ-

ment to large and ever-increasing numbers of men, it does not grieve me to see new mines being opened up in Qubec or Manitoba. On the contrary, and I think that all mining men will agree with me; it is the best thing that can happen to this country. We cannot be hurt by the prosperity of our neighbours. Mining is interprovincial in scope and pays no attention to provincial boundaries. The mining men of Ontario take some legitimate pride in the fact that they have been the pioneers in opening up the new gold camps of Quebec, and some of the most important gold mines of that province have been financed, and are still controlled, by Ontario companies. Thus, our Province does indirectly benefit through the opening up of these new sources of richness.

I hope I have not kept you too long but my subject was very vast and I have hardly touched it. It was worthy of a better exponent but, dry as I have been, I hope that I have been able to convey to some of you an idea of the great and always increasing importance of the mining industry in Ontario.

PLANTS AND CIVILIZATIONS*

By E. D. MERRILL

We accept our cultivated plants and domesticated animals for granted. The average individual seldom gives a thought as to whence they came, how they originated, and when and how they were disseminated. All cultivated plants and all domesticated animals are manifestly derived from wild species. It is a well established fact that every important plant species now in cultivation, of basic importance to our food supply, was cultivated somewhere in the world at the dawn of recorded history, and the same statement is true in relation to all our domesticated animals. While modern man has greatly improved the numerous species of plants and animals domesticated by his prehistoric ancestors, and has originated numerous special forms or varieties by selection and by hybridization, he has not added a single important species to the long list selected and developed in the long prehistoric period of man's existence.

When one scans the list of species of cultivated plants and domesticated animals in reference to their place of origin, i.e., their original homes, one is impressed with the fact that nearly all of them came from certain restricted areas in both hemispheres. These are certain parts of Asia Minor, Central Asia, Northern India, certain parts of China, and perhaps Abyssinia in the Old World, and the highlands of Mexico, Peru and Bolivia in America. All of North America north of Mexico, most of South America, all of Australia, most of Africa, and the greater parts of Asia and of Europe yielded nothing of importance.

Again one notes that these restricted areas, in which the ancestors of our cultivated plants and domesticated animals originally occurred as feral species, are the same regions in which early civilizations originated. There is thus a very close correlation between the places of origin of the species of both plants and animals on which man largely depends for food, and the places of origin of early civilizations. Manifestly all advanced civilizations are depen-

* An abstract of a lecture given November 7, 1936. For a fuller account see Merril, E.D. Plants and Civilizations. Sci. Monthly 43: 430-439. November, 1936.

dent for their continuation on a permanent food supply. Likewise early civilizations could not have been developed at all without the leisure resulting from the actual cultivation of plants and the utilization of domesticated animals, which ensured a permanent and dependable food supply. In the hundreds of thousands of years that man has been on earth, probably no single factor has been of more importance to the future of the human race than that economic revolution occasioned perhaps 15,000 years ago by the discovery that certain food producing plants could be cultivated, thus ensuring a dependable food supply. Agriculture is not the discovery of any one people but unquestionably originated independently in widely separated centres in both hemispheres.

When one considers the dissemination of cultivated plants and domesticated animals, one is again impressed by another striking fact. Up to the close of the fifteenth century, not a single cultivated food plant, and not a single domesticated animal, except the common dog, was common to the two hemispheres. In other words, the early American cultures were developed locally on the basis of an agriculture that, in turn, was based on strictly American plants and animals, and the Eurasian civilizations were based solely on plants and animals, natives of certain restricted parts of the Old World. In both hemispheres agriculture, or the cultivated plants themselves and the art of caring for them, was disseminated far in advance of the early cultures that were based on it. This must have been by diffusion, for primitive peoples in the remote parts of both hemispheres, thousands of miles from the regions in which the plants were first brought under domestication, were in possession of them as far back as our records extend. An excellent example of this is the maize, beans, pumpkin, squash, and tobacco, all originating far to the south in Mexico, Central America, or South America, widely cultivated by the Indians of the north-eastern United States and southern Canada long before European colonization of America commenced.

Following the discovery of America by Columbus came the great expansion of the European civilizations and the period of colonization, with the universal distribution of the economic plants and domesticated animals of both hemispheres. Early civilized man was limited in his contacts by continental boundaries, and, while in both America and Eurasia he disseminated his cultivated plants and domesticated animals to the extremes of their possible ranges within the one hemisphere or the other, he could not, or at least did not, exceed the limits of the one continent or the other.

It was perhaps but natural that the early observers in America should attempt to explain what they found here on the basis of their European experiences, hence the numerous theories that were proposed in the sixteenth and seventeenth centuries to explain early American civilizations on the basis of ancient contacts between Eurasia and America, involving the peoples of Mesopotamia, Egypt, Phoenicia, Greece, Rome, Wales, Ireland, those of India, China and Japan, and even the "lost tribes of Israel." For all of these theories, including also the Atlantis and the Mu propositions, our evidence clearly indicates "not proved," but rather that the early American civilizations were developed from very primitive cultures utterly independent of Eurasian contacts.

Thus the rather large public that believe implicity in the existence of an ancient Atlantis that explains both Eurasian and American civilizations, and the equally ardent but fewer disciples of an ancient continent of Mu in what is now the Pacific basin, that similarly explains the cultures of both continents, may be disappointed to have their beliefs shattered by this very simple but absolutely basic fact; in pre-Columbian times there is absolutely no evidence of contacts between the advanced peoples of the Old and the New Worlds on the basis of their agriculture. Had contacts existed, it is inevitable that some of the plants and animals, on which the ancient civilizations were based, would have been transmitted from one continent to the other long before the close of the fifteenth century.

Among the ethnologists, that school of the extreme diffusionists who predicate the origins of all important advances and inventions to one place and one people, and their later gradual dissemination over the entire world, gains no support. The biological-agricultural evidence does not conform to the preconceived theory. This evidence is absolutely and wholly in support of the theory maintained by most conservative ethnologists, that man entered America from Eurasia as a primitive nomad over a northern route. Once here, he gradually worked southward, there undoubtedly having been wave after wave of invasion. The first emigrants doubtless came before agriculture was developed in that part of Asia whence they came, for if they came after agriculture was developed they would have lost all knowledge of the art in the many generations involved in their expansion southward through a region inimical to agriculture. When man reached Mexico, and this meant many generations, he came in contact with certain native food producing

plants. In the course of many centuries, he gradually learned that some of these were adaptable to cultivation, and later he there, and in South America, gradually developed an agriculture utterly independent of Old World contacts, and, in time, on the basis of that agriculture ultimately developed the high civilizations characteristic of the pre-Columbian Mexico, Yucatan, Central America, Peru and Bolivia. The biological-agricultural evidence is absolutely and wholly opposed to Eurasian-American contacts from the time that man as a primitive nomad entered North America up to the close of the fifteenth century. Such similarities as do exist between Eurasian and pre-Columbian American civilizations in architecture, sculpture, hieroglyphics, civil, political and ecclesiastical organization, or in any other advanced art, may be looked upon as purely accidental resemblances, the disciples of Atlantis and of Mu, and the extreme diffusionists to the contrary notwithstanding. There is no occasion to look to either Europe or Asia to find the sources of early American civilizations, which, like the agriculture on which they were based, were purely autochthonous.

EARTHQUAKES IN EASTERN CANADA AND ADJACENT AREAS

ERNEST A. HODGSON.

Some years ago, the writer was spending the night in a tourist camp near Schenectady, N. Y. The camp superintendent, making his rounds, was chatting a few minutes with the members of each car group. In reply to his direct question, we ventured the confession that our business was the study of earthquakes. His manner became instantly that of the embarrassed man who finds, in his tour of the grounds of an institution for the feeble minded, that he has been talking to an inmate instead of an attendant. He muttered something to the effect that earthquakes never happened in that locality and left precipitately.

As a matter of fact, earthquakes have been felt from time to time in or near Schenectady and the same may be said of many places in eastern Canada or New England. Yet, so evanescent are our impressions of earthquakes, acutely conscious of them though we may be at the moment, that most of us would probably be inclined to inform tourists from distant countries that we in eastern Canada never have any earthquakes to speak of. Some might add the Gilbertian "Well! hardly ever!" A few would have much to say about one or the other of the larger earthquakes—the one with which each had had personal experience. Given the set task of obtaining an accurate and complete account of earthquakes in eastern Canada and adjacent areas, what sources of information are available? They may be briefly set forth in tabular form as follows.

SOURCES OF INFORMATION:

EARTHQUAKES IN EASTERN CANADA AND ADJACENT AREAS.

(See Note, page 31)

1. Newspaper files, reports of officials of religious, civil, or military organizations; reminiscences of "oldest inhabitants"; scientific papers; sermons; etc., covering the period from earliest times to about 1927.

2. Long period seismographs, capabl of recording only the larger tremors or those originating very close to the station; covering the periods since the following installations (series of dates indicate installations of successively-more-sensitive seismographs): Toronto, 1898, 1923; Ottawa, 1906, 1912, 1822, 1937; Halifax, 1915; Seven Falls (near Beaupré, Que.), 1925.

3. Short period seismographs, capable of recording practically all seismic tremors within 200 miles of the station and all tremors of importance in the region covering the period since the following installations: Shawinigan Falls, 1926; Seven Falls, 1927; Ottawa, 1937.

The first group of sources has, from time to time, furnished data which have been compiled in a card file at Ottawa. All information received, covering the period from earliest times to the end of 1927 (when the first short period seismographs began to record), is entered as obtained. Each entry leads to the investigation of other possible sources which, in turn, yield further details. Up to the present time, 380 earthquakes have been listed, of which the tremors of February 5, 1663; September 5, 1732; December 6, 1791; October 17, 1860; and October 20, 1870, were quite severe. The exact epicentres cannot be determined but each was centred in or near the Saint Lawrence valley, below Montreal and above Tadoussac.

Long period seismographs supplement the records since 1898. This class of instrument does not ensure that all small tremors will be recorded, but it does furnish more detailed information about the larger earthquakes. It is possible to determine, with some degree of precision, the epicentres of these larger disturbances. In

Note:—From 1898 to December, 1936, the stations at Toronto and Victoria were operated continuously by the Meteorological Service, Toronto. The other stations have been operated continuously from the dates of their respective inaugurations by the Dominion Observatory, Ottawa. On December 1, 1936, the Seismological Service of Canada was re-organized, the Toronto and Victoria stations being brought, together with the others (including one at Saskatoon established in 1915), under the administration of the Dominion Observatory. The station at Halifax is run with the co-operation of Dalhousie University; those at Seven Falls and Shawinigan Falls with the co-operation of the Shawinigan Water and Power Co.; that at Saskatoon with the co-operation of the University of Saskatchewan; and the one at Victoria at present, with the co-operation of the Meteorological Office, Victoria. It is planned to move this last station to the Dominion Astrophysical Observatory, near Victoria, as soon as arrangements can be made.

the period 1898-1924, earthquakes of this type were experienced at Morrisburg, Ont., April 28, 1913, and at Labelle, Que., February 10, 1914. There must have been many other small tremors during this period but they were not sufficiently well defined on the long period instruments available to permit of their being located. Many were not recorded at all.

The earthquake of February 28, 1925, was felt over an area of at least 500,000 square miles. Reports were received from the Atlantic coast to Duluth and from points as far south as Washington. The writer was assigned the task of studying this earthquake in the field, determining the position of the epicentre, the time at the origin, and the extent of the damage. The earthquake took place a little after 9 p.m. E.S.T. The first trip of inspection was begun on March 5 and continued to March 21. A second trip, April 2 to April 17, was undertaken after the snow had melted.

The epicentre was found to lie in the bed of the St. Lawrence about midway between the mouth of Rivière Ouelle on the south shore and that of the Malbaie river on the north. There were few stone or brick structures in the immediate vicinity of the epicentre but these few were damaged beyond repair when on deep alluvium and very considerably shaken and cracked when on rock. Practically all chimneys within twenty-five miles of the epicentre were shaken down. Most of the houses in the vicinity were frame and the damage was confined to the breaking of chimneys and windows, and the breaking of overturned furniture, stoves, dishes, etc. Although the weather was cold and the earthquake occurred at night, no fires were caused, no person was killed, and no one was seriously injured. Four persons were said to have died of the shock and, in at least two cases, this seems to have been established.

The tremors were so severe that property was damaged at Quebec City, at Three Rivers, and at Shawinigan Falls. In every case, however, this was due to the structures being on deep alluvium. In some cases poor construction played a part in the destruction caused; in others the structures were of good materials but poorly designed to resist earthquakes. In all, it has been estimated that damage to the extent of $100,000 resulted from this earthquake.

One effect of the Saint Lawrence earthquake, as it has been called, was to stimulate interest in a study of the seismicity of eastern Canada.

With the co-operation of one of the power companies, vaults were built at Shawinigan Falls and at Seven Falls (near Beaupré,

Que.). A short period horizontal seismograph of the Wood-Anderson type was installed at each place and, in addition, a long period seismograph was added at Seven Falls. Thus began the recording of small tremors in eastern Canada and adjacent areas,—the third type in our sources of information. These short period instruments were run experimentally for a while. It was not until the fall of 1927 that systematic continuous recording was begun. Since then about fifteen earthquakes per year, on an average, have been detected in the region under investigation. Unfortunately, owing to a lack of collaborating stations, the exact epicentres of most of these could not be located. Some were located fairly closely with the help of local correspondents or by means of press reports.

On November 18, 1929, an earthquake occurred to the south of Newfoundland, off the Grand Banks. Tidal waves rushed up the bays of the south shore of Newfoundland causing considerable destruction and resulting in twenty-seven deaths. Twelve of the twenty-one Atlantic cables were broken, most of them in many places for a distance of 200 miles. The earthquake stimulated investigation of early records. It was found that, in 1774, there was a tidal wave in the lower Gulf resulting in 300 deaths. This was very likely caused by an earthquake. The first north Atlantic cable was ruptured shortly after it was laid in 1856. The cause of this may have been an earthquake, but it is more likely to have been due to some other strain. Cable breaks occurred in 1863 and in 1890, but there is no record to show that these were caused by earthquakes.

The study of the tremors in eastern Canada raised the question of the seismicity of the Arctic. A study was undertaken in 1929. It was found that, since continuous recording began about 1900, the only earthquake which had occurred north of Canada was one off Bank Island, a little east of the mouth of the Mackenzie river. This is well outside the region now under consideration. On November 20, 1933, a severe shock was located as having occurred in Baffin Bay. This might be considered as being part of our "adjacent area." Two shocks, of lesser intensity, have been located since in Baffin Bay. These three shocks are the only ones of which we have record as occurring in the region north of eastern Canada.

About 1 a.m., November 1, 1935, a severe earthquake was felt over a wide area in Canada and the United States. The tremors were reported from as far south as Washington and from near Winnipeg to the Atlantic. The Dominion Observatory made a prelimin-

ary location of this earthquake, from records, as being about thirty-five miles north-north-east of North Bay, Ont. Subsequent field work and further study located the epicentre about four miles north of the town of Timiskaming, Que. It was at first thought that the focus was about 125 miles below the surface, but study of the records during the past winter has shown that the focal depth was very much less than that,— probably of the order of ten miles. In spite of the wide spread distribution of the felt tremors, the damage was slight. The town of Timiskaming was so nearly over the focus that the tremors arrived in nearly vertical paths. The chimneys were so shaken that they had to be rebuilt but they did not fall because of the direction from which the shock arrived. This is the latest of the major shocks in the area considered.

In April, 1937, a vertical Benioff seismograph, with both long and short period recording, was installed at Ottawa. Similar equipment had previously been placed in operation at Harvard, Mass.; and, at about the same time, vertical Benioffs were installed at the University of Vermont, Burlington, Vt., at Williams University, Williamstown, Mass., and at the Jesuit University at Weston, Mass. These, together with the short-period instruments at the two Quebec stations, afford a well-distributed recording system. A joint program of research is now the subject of consideration by those in charge of these stations, which should make it possible to record every "local" tremor and to locate many of them; so that, from this time forward, seismological research may hope to have a much more complete history of the **Earthquakes of Eastern Canada and Adjacent Areas.**

INDIANS OF THE SOUTH WEST

ELLSWORTH JAEGER

This evening's lecture is a brief resumě of a delightful exploration trail into the Southwest, which it was my good fortune to follow for the last three years.

To begin with, the land itself is unreal, fantastic, beautiful beyond description, not of this earth as it were, and it is here that the centuries of the past still live in the minutes of the present. It is a land of enchantment, indeed, for here you can walk with the men of the Stone Age, descendents of the Conquistadors, sons of the pioneers and modern men of the high pressure Twentieth Century.

It is no trick at all to roll back the curtains of the past and to peep into living books of archaeology, for here, in the Rio Grande valley, one can wander among the Pueblo folk very little changed by the white civilization of a paltry three centuries.

The Pueblo Indians are divided into several linguistic stocks, but their cultures are very similar. When the first Spanish explorers came into New Mexico they found these Indians living in towns much the same as they do today and so they called them "Pueblo" Indians, pueblo being a spanish word for town.

The pueblo of Taos is, perhaps, the best known Indian town today. Here you will find the first type of apartment house or tenement that was developed in America. The several storied buildings of mud are really apartment houses, for they shelter a number of families. With the majestic range of the Sangre de Cristo Mountains for a back drop, this pueblo is, perhaps, the most dramatic of Indian towns.

To show you from whence the Pueblos received their architectural inspiration, I show this slide, for here is a little Indian church at Sia Pueblo. At a distance is a butte, formed by the winds and rains of centuries, that might well be its twin, for both butte and church are almost alike in outline. Thus we realize, that the Indian went to nature, not only for his food and building material, but for his architectural ideas as well.

In every pueblo you will find well tended fields and gardens and, in each, tiny orchards thrive, living mementos of the Spanish padres' work among these people. The fruitfulness of the South-

west, when water is at hand, seems almost magical so bountiful are its harvests.

The Indians of the Southwest, in many instances, still follow the ways of their prehistoric ancestors. Although they are well acquainted with modern farming and its implements, many Indian farmers still use the ancient digging stick and the rituals and songs of fertility and rain. The digging stick is made from a crotched sapling, resembling a stilt in form. This the Indian farmer thrusts into the ground every few feet. His wife, who is following, drops the seeds into the openings and heaps the earth over them. The fields are then watered by hand until the rains come, when the water is diverted from the streams by means of irrigation ditches to each growing plant. Stone age magic and invocation is thought more important than care and fertilizer, and, judging from the results, it is certainly good medicine, for the Southwestern Indian is one of the finest dry farmers on this continent.

During the summer the plazas of the pueblos sometimes present a strange sight. It would seem that the Indians are decorating a number of modernistic Christmas trees. But they are merely drying melons for winter use. A number of saplings with lopped off branches are planted in the earth of the plaza floor. The melons are peeled and cleaned of seeds, and then suspended upon each lopped off branch until they are dry. They are then torn into long strips, and these strips are tied into bundles and suspended from the rafters of the houses, until the housewife desires melon for a winter supper. The dried melon is then stewed or made into pie, very palatable but slightly fermented at times.

In each pueblo several round adobe buildings are seen. These are the kivas or sacred lodges of the Indian. It is here that the most sacred and intimate of the ancient rituals take place. These buildings are jealously guarded and very few white men have ever seen the interior. It took me over two years to make enough close friends to be allowed to peep in through the hatchway. It was then that I witnessed, perhaps, one of the strangest ceremonials, for, in the gloom of the interior, a priest was making soap bubbles. This may sound humorous to the listener, but this Indian medicine man was never more serious in his life. He was making rain medicine. As he blew a beautiful iridescent bubble from the yucca suds, he breathed a prayer for rain into it. When it was released it floated upward through the hatchway up into the clouds, where the rain gods are supposed to dwell and where it burst and revealed

the prayer, a plea for rain, so harvests would be fat and families large and fertile. The beauty of the imagination of these folk, who conceived such exquisite receptacles for a prayer, must be beyond all bounds.

During the rain dances, a chorus of old men usually chant the songs. So old are these songs that, in some cases, the meanings of some of the words have been forgotten. Accompanying the singers is the huge Southwestern drum or tombe, made of a hollow cottonwood log with steer hide for drum heads. So compelling is the rhythm of the songs and drums, that your heart literally beats in harmony with it, when you sit on the roof tops and listen to its magic hour after hour, with dancers weaving a glorious pattern of color before your eyes.

Accompanying the chants, at times, are ancient musical instruments. The bull roarer is such an instrument. It is made of a flat piece of wood with a thong at the end. This is whirled about the head of the musician and it makes a roaring sound, that the Indians say is the voice of thunder. They call it the "Thunder Maker."

Another ancient instrument is called the biorache stick. This is a notched stick, held upon an inverted bowl, which acts as a resonator. Another stick or a deer's shoulder blade is rubbed back and forth upon it. This makes a sound something like that which a boy makes rubbing a stick upon a picket fence. This may seem like strange music to you, but it is nevertheless in pleasing harmony with the Indian music.

Sometimes strange ceremonials may be witnessed. At Zuni pueblo the sword swallowers hold forth. Here the Indians actually swallow wooden swords, the blades of which are eighteen inches long or more. Both men and women participate in this dance. As they dance, they are not satisfied to swallow one sword, but take a second, a third and even a fourth into their throats at the same time. I knew a member of this sword swallowing fraternity, and so one day I asked him why he swallowed the swords. Since this is a very secret fraternity, he was unable to reveal the raeson, and so he put me off by saying that it was good for sore throat. And so here you have, perhaps, a Zuni prescription for treating sore throat.

Masks reach the highest form among the Zuni and the Hopi of Arizona. Here, perhaps, you will see the greatest and most beautiful collection of masks ever conceived by primitive man. When you witness the numerous and colorful masked figures taking part

in the rites, it seems as if the characters of the myths and legends of these people have come to life.

Among the strange masked figures at the Hopi dances is "Macidoe" the Sun God. Since he is the Sun God, he controls the storms and so he has the lightning on his mask. He also carries the lightning under his arm, which is symbolized by a grotesque serpent. The Indians think the lightning, writing across the sky, resembles a snake and so they picture it as such. In this instance the snake is really the beginning of puppetry for this is exactly what it is. The performer has his arm within the snake's body, grasping a stick, which is attached inside the head. By this means, he moves the serpent about in a most life-like manner. When you see him weaving about in the fire light of the kiva, he makes you feel, that here, indeed, is a mythological creature come to life.

One cannot wander very far without being impressd by the arts and crafts of these people. Among the Pueblo, pottery seems to be the outstanding craft. These folk can be considered among the finest potters, ignorant of the potter's wheel, in the world. In order to record the process of Indian pottery making, I made a detailed inquiry.

In making pottery the Indian gathers the clay, which, strange to say, comes, not in the form of clay, but of soft earth. This earth is ground into fine powder between two stones. The pulverized earth is then winnowed by dropping it from a height. The wind carries the finer particles off to one side, and it is these fine particles that are used in the making of pottery. A tempering material is added consisting of crushed rock or crushed pottery that has already been fired. This prevents the pottery from cracking, when baked. These combined materials are mixed with water and kneaded into a dough-like mass. A chunk is then placed upon a saucer-like mold and with the palm of the hand the base of the pot is formed. When the base is moulded, the sides of the pot are built up with ropes of clay. These are formed by rubbing the clay between the two hands. One coil at a time is placed on the pot and pinched into place. When the sides have been built to the desired height, they are smoothed and shaped by means of a gourd tool called a "kojepe." By its aid the pot is shaped and smoothed to the satisfaction of the maker. It is then allowed to dry thoroughly, after which it is scraped with a knife or tin can top. This smooths it, as if it were sandpapered. It is now ready for the slip which is made of colored clay diluted in a great deal of water. The slip is

applied with a folded rug. Before it is dry the pot is polished with a small water-worn pebble. This gives the pot a glazed appearance, the soft lustre commonly found in Indian pottery.

The potter's next step is decoration. In applying the design the Indian uses a brush made from the narrow leaf of the Yucca. The leaf is chewed until the long fibres are freed. These make the hairs of the brush and they are trimmed and thinned, until the desired type of brush is made.

The designs applied are usually symbolic of water, rain, fertility, etc. We, who live in a temperate climate with enough rain, do not realize how important this element is, until we visit the desert areas. Then we realize that rain and water mean life itself, for, without it, living things would perish. And so the Southwestern Indian takes every opportunity to ask the Spirit sources for this greatly desired gift.

In firing the pottery, the Indian places the pottery, mouth down, upon rocks or tin cans or a grate and then places kindling beneath. Large cakes of sundried dung are placed around in a wall and other cakes are used to roof it over. The whole mass is then set afire and, in about twenty minutes, the pottery is baked and ready for use.

Should the potter wish to change the color of the pottery from white, yellow, red, or brown to a beautful glossy black, she does not paint it black. She merely smothers the baking fire just before the pottery is entirely fired. This lowering of the temperature evidently carbonizes the colouring matter, changing the red or white or yellow to the glossy black.

The black paint used in outlines upon the pottery is made from the Mountain Bee plant. Just before it reaches maturity it is gathered and boiled until a sticky mass results. This is dried into cake form like India ink. When needed, warm water is mixed with it and the paint is applied. It looks greenish in color when painted, but the firing burns it to black.

At Cochiti Pueblo I came across an interesting legend about the common black beetle that is seen hurrying every direction. If you come close to this hurrying traveler, however, he suddenly stands upon his head and so they call him, "the beetle, who stands on his head."

While sunning myself with sôme Indians one morning I saw this beetle pass by. Thrusting out my foot, I intercepted him and

he immediately stood upon his head. I asked my Indian friends why he did this. After some time I managed to get this story from them.

It seems that this beetle had the job of placing the stars in designs in the sky. He managed to get quite a few designs there. You can see them today if you look at the various constellations. After a time, however, he grew curious to see what the world thought of his work and so he looked toward the earth. He saw that everyone on earth was watching him with open mouthed awe and admiration. This so filled him with conceit, that he thought more about his own importance than the importance of his job. And of course he then grew careless. Suddenly he dropped the bag of stars and they scattered over the sky. These formed what we call the Milky Way.

The Indian said, however, that this beetle is so ashamed of himself that, on meeting anyone, he immediately tries to hide his head in shame. That is why he stands upon his head.

When you travel westward into the mountains and deserts of Arizona, the Pueblo are left behind and the Navajo country is reached. The Navajos are of Athapascan origin and call themselves "Dinneh" which means **The** people. And by their attitude and carriage, they impress this upon every one who sees them. Being Nomads, they roam over a country as large as Rhode Island, Connecticut, Massachusettes and New Hampshire. It is a beautiful land, a land where some story book giant shivered a rainbow into bits and scattered the fragments over its length and breadth. Being roving Indians, the Navajos build only brush shelters in the summer and it is not at all uncommon to see the family living in these temporary shelters. Here you will find the ever present loom, upon which they weave their glorious blankets. About them will be feeding their goats and sheep.

In winter, however, they live in a more substantial dwelling called a "hogan." This is built of earth and logs, usually eight-sided with a mound-like roof. A hole in the roof allows the smoke to escape. The door always faces East.

The Navajo man is sometimes an excellent silversmith. This he acquired from the Mexicans and Spaniards in the early days, but he has become so expert now, that he excels his teachers. The beautiful silver work, which he creates with the crudest of tools, is always amazing to the newcomer.

Another art is that of dust or sand paintings. These sand paintings are really illustrations of their myths and legendary gods and characters, and are used only for sacred rites. The medicine men create these exquisite designs by dribbling colored dust between their fingers. To achieve the rank of medicine man, the novice must memorize some 350 sand paintings with all of the chants and rites that go with them. This would seem to be quite some mental gymnastics, for many of the paintings are most intricate in design.

Many of these sand paintings are used in the Mountain chant. Here too, magic and slight of hand tricks come to the fore. One trick called that of the magic Yucca is performed in this way. A number of performers come out and sing and dance. Suddenly they huddle together and when they separate a Yucca plant is found growing where none grew before. After repeated huddles, the plant grows, flowers, and fruits, all in the small space of fifteen minutes.

Another Navajo trick is their arrow swallowing. Unlike the Zuni, who actually swallow swords, the Navajo only make believe they swallow the arrow. The arrow in question is so constructed that the fore part of the shaft gets into a hollow reed at the back. When the arrow is thrust into the mouth, the shaft telescopes into the reed. To all appearances, it looks as if the Navajo had swallowed the arrow.

In Navajo Land, the mother-in-law question has long been solved. Here the Navajo never looks upon his mother-in-law. Since many of these Indians are polygamous, they have a number of wives and sometimes a number of mothers-in-law. So it is, perhaps, to his advantage after all that he does not communicate with his many mothers-in-law. The Navajos believe, that should such a thing take place, the parties involved would become deaf or blind or some other dire calamity would fall upon them.

Divorce is comparatively simple among the Navajos. The children belong to the mother's clan. She also holds all things inside the hogan, except her husband's personal belongings. Should the Navajo woman wish to get rid of her husband, she merely places his belongings outside the hogan. This notifies him that he is through, and so he usually goes back to his family. The Navajo woman is, perhaps, the most independent of her sex anywhere.

The beauty of the country has made a profound impression upon the religious background of the Navajo and his can be called a religion of beauty. In closing I can perhaps give you an idea of the

attitude of these Indians toward the beauty of their land by quoting a prayer I heard an old medicine man chant several years ago.

He said:

"In the house of the dawn,
In the house of the twilight,
In the house where the rainbow people dwell,
Let me ever walk upon a trail of beauty.
Let beauty guide me,
Let beauty follow me,
Let beauty surround me all the days of my life.
And when my life is finished,
May it be finished in beauty."

SCIENCE IN CRIME DETECTION

WILMER SOUDER

I bring to you the greetings of the National Bureau of Standards and wish to express an appreciation of the honor conferred in requesting a member of its staff to address the Royal Canadian Institute.

The word crime does not harmonize with the thoughts and activities of your daily life, and, for that reason, much of this lecture may seem awkward. There are no "good" crime stories. One might as well ask for an "awfully" good meal as to expect the rehearsal of pleasant details of a crime. Crime carries with it the violation of rights or injury to others, and worse yet is the fact that the violation or injury is intentional.

Among out first laws is the instruction: "By the sweat of thy brow shalt thou eat bread." This need not be construed wholly as a curse. It can also be interpreted as a promised reward for effort, in that it concerns those who labor. Surely these are entitled to the enjoyments of food.

Many individuals fail to adjust their lives to this ancient code and are not willing to accept rewards measured in terms of their efforts. They prefer to appropriate those things which rightfully have been earned by others. Quite naturally these violations are not made openly or in the presence of those who accept the code of behavior set up by the State.

It is not possible to repeat the flow of time and witness a reenactment of the crime. Attempts to construct the sequences of the actions and the parts played by the actors must depend upon the evidence which remains after the completion of the act. This evidence may be the product of an active conscience which compels the criminal to confess his guilt. It may be the observations of an eye witness. Too frequently it is only fragmentary traces, a bit of writing, markings, unusual coincidences in the behavior of individuals or statements which cannot be verified. From these bits of evidence, the investigator must orient his labors if he expects to solve the problem.

The key to the solution may be very simple. A few written words or characters, scratches on a bullet, marks on an object, the theme of a letter, a conversation, or a careless act by the individual prior to the act may disclose the motive or technique and point directly to the correct solution. The driver who parks his auto and leaves a large number of keys attached to the lock may tempt an attendant or prowler to remove or reproduce one or more of these keys. Thereafter access to the home or office is readily obtained. A member of a family may describe jewels or other precious wares with such enthusiasm that servants absorb part of the enthusiasm and, innocently or intentionally, convey information which will lure others to convert the valuables.

The superiority complex of the man who feels that he is the exception and that he can "beat" the gambling game frequently prefaces the career of crime. One taste of easy money breeds the desire for more easy money. A forged check, duplicate bond, changed contract, or a gun thrust in the face of a cashier may win more money in a few minutes or hours than the individual could earn in a lifetime.

Most men at some time during their life come to a realization of the fact that they may not, if present conditions continue, achieve fame or amass a fortune. Some become unsteady and try for immediate results. In many instances they display traits common to the mentally defective. The behaviour of these individuals during this period is indeed peculiar. They seek, not the advice of established friends, but rather the advice of strangers who can paint a glowing picture of future fame and success.

The partially intoxicated man frequently, upon a realization of his excessive indulgence, overacts in an attempt to show that he can walk a line or converse intelligently on numerous subjects. The audience is supposed to conclude from these acts that he is normal and not intoxicated. He unnecessarily exposes and emphasizes his weakness.

Criminals frequently overact in their attempts to construct alibis. The writer of a threatening or obscene letter may send a similar letter to himself. The motives and driving forces which lead to crime must be understood by all successful criminologists.

All types of investigators are necessary in solving our numerous crime problems. The 225-pound sergeant, with ten years experience, has a technique which frequently brings results. At the other extreme is the suave phsychiatrist who likewise secures excellent

results. Officials must, at times, depend upon the statements of suspects or informers for their leads. Everyone realizes that neither spoken words nor written words are necessarily true. There may be inflections in speech, conflicting statements, or displays of emotion which reveal facts very different from the written or spoken statements. As we pick up these facts, concealed by words but revealed by other senses, we enter the field of scientific crime detection. A written document contains, in addition to the words or message written thereon, a style, a theme, a technique and, if it is handwritten, it bears those acquired peculiarities of letter formation which, so frequently in the hands of an expert, reveal its author.

Handwriting experts are familiar with the styles of writing commonly employed. They recognize instantly the departures from normal or perfection in writing. Each style of writing has a dominant motif which extends through the entire alphabet. When different letters in a document, apparently written by one individual, reveal different motifs, the expert recognizes an attempt by the writer to disguise his identity. There are methods whereby such attempts may be eliminated. A fairly accurate representation of the author's style and peculiarities can usually be established, if sufficient materials are available and the expert is willing to put forth the effort. The peculiarities in individual writings must be recognized. Their significance must be evaluated. Nationality, profession, physical condition, and age are sometimes shown to such a degree, that a fairly accurate statement concerning these features can be made. When a sufficient number of these peculiarities in writing characteristics, all pointing to one individual, are discovered they indicate to the expert, beyond all reasonable doubt, who wrote the document. The case is then completed and frequently is stronger than a case built upon oral statements from the suspect or those who claim to have witnessed the event.

Perhaps the definition of an expert will be of interest. According to a good authority, an expert is "one who has acquired by special study, practice and experience, peculiar skill and knowledge in relation to some particular science, art or trade." We must correct the popular idea that the expert is one who knows everything and who cannot possibly make a mistake. If we regard the expert as "eyes" to aid the court or jury in discovering the evidence, we shall not be far from the proper conception.

While it is true the expert may express to the court or to the jury an opinion, the more accurate and the more modern conception

of his function is to explain, in the light of known facts, the reasons for his opinion so that the jury may, through his aid, accurately interpret the evidence. The opinion of an expert, without an explanation of the reasoning supporting the opinion, is of little value to an intelligent jury or audience. If this function is achieved perfectly, the jury will really understand the evidence and will come to the same conclusions, and their opinion will agree with the opinion of the expert. It is no discredit to a jury to state that all of its members may not be experts in the fields of science. No one man can be an expert in all fields of science, but any expert worthy of the name can interpret his work so that the normal man can understand it and relate it to those things which he experiences in his daily life. The expert has no occasion for conceit or a haughty attitude. He is, if he meets his obligations, a servant. The dog which sets and hold the quail for the hunter is an expert to the hunter. It is possible for an expert quietly and with pride to perform his duties and in no way appear to be different from the average citizen.

The expert must see the evidence. He must not fail to see all of the evidence. He must be able to explain in simple and familiar terms the significance of the evidence placed in his hands. He must recognize errors or inconsistencies. When our Census Bureau announced that 85 women in the United States earned their livings through hunting and trapping some one facetiously remarked that the digits 8 and 5 were probably correct but that it was evident 4 or 5 ciphers had been omitted. (Perhaps his study and experience had given him peculiar knowledge in relation to this art).

There will always be a division of opinion as to which type of evidence is most reliable. Many prefer the so-called direct or eyewitness type over the indirect or circumstantial type. Those who insist upon eyewitness evidence would be embarrassed if tornado insurance companies insisted upon proof of loss through eyewitness identifications of the winds or other forces producing the damages. Physicians diagnose hundreds of maladies without actually seeing the causative organisms. Chemists make our world a garden of paradise without actually seeing the atoms and molecules responsible for our comfort. Eyewitness testimony is so frequently in error. The magicians entertain us and enhance their bank accounts through the mistakes made by our eyes. The young lady put her pastor on the spot when she asked. "Shall I marry a man whom my friends claim is lying to me?" The wise counsellor, knowing

humanity, gave his answer in the form of another question: "My dear girl, do you desire to become an old maid?" Conclusions based upon orderly scientific investigations and interpreted in terms of the experiences of humanity are seldom in error and cannot, under proper cross examination, long remain in error.

One difficulty in law enforcement arises from the attitude of those good citizens who always ask for another chance for those brought before the court to face the evidence and receive the prescribed penalty. Some go so far as to oppose unqualifiedly all forms of capital punishment regardless of the nature or the horror of the crime, the adequacy of the evidence, and the premeditated wilfulness of the act. This phase of law enforcement may be reflected in a failure by a jury to convict, thus nullifying all evidence presented. Science as applied to the detection of crime must not, under any circumstances, be blended with sympathy. We need not take issue with a law prescribing capital punishment. The following quotations are from the greatest Book of Law, Sympathy and Understanding the world has ever known:

> "It is better for him that a millstone were hanged about his neck, and he were cast into the sea."
>
> "But if thou do that which is evil, be afraid; for he beareth not the sword in vain."

A man, with a millstone about his neck, cast into the sea is not apt to encounter much sympathy on his journey. Neither was the sword an article of jewelry or personal adornment at the time those codes were formulated.

The cold, impartial nature of scientific evidence should not cause us to feel that it is cruel. We must not permit our sympathies to distort facts. Laws and the execution of laws are entirely separate from evidence. There are always methods for extending clemency where clemency is appropriate, and this may be done without discredit to the facts which convicted, or to the law which named the punishment for a definite crime.

The susceptibility of a jury to court room displays of emotion, and the apparent usurpation of power to prevent a conviction by a divided or not-guilty verdict is receiving careful and serious thought throughout the civilized nations. Holland, a nation of practically no crime, tried and discarded the jury system years ago. Other European nations have discarded the promiscuous or

haphazard methods of selecting juries without regard to standards, and now select only citizens possessed of the highest qualifications for this important service to humanity. In some instances, crimes of highly emotional or passionate natures are not permitted to go before juries chosen by lot from the common lists. The power of one juror alone to neutralize completely the serious judgment of eleven jurors is being regarded by many as an unequal victory against the State. Although the crime laboratory feels the effects of such entanglements it does not have to accept a demerit for their results, and we may leave this problem to the experts in jurisprudence.

The danger of convicting the innocent has been recognized through the ages. Mistakes have been made and will doubtless continue to be made so long as mankind rules the earth. The best prophylactic against an unjust conviction and the best antidote after an unjust conviction is a record of prior usefulness, a well organized life, and a definite separation from those practices which are antagonistic to the best interests of society. Those who fail to be interested in or to earn these merits early in life have no right to invoke the rewards of a parole, commutation of sentence or any other favor from a civilization in which many are "by the sweat of their brows" advancing the welfare of the human race. "No rogue ever felt the halter draw with good opinion of the law."

A most decisive victory for scientific crime detection came after the war in Europe. Scientific crime detection had been taught in special schools for many years prior to 1914. Austria, England, France, Germany and Switzerland, because of their peculiar problems, recognized its value and trained students in this profession fifty or more years ago. Austria was one of the first to give courses of university grade in this subject. When propagandists and revolutionists began converging upon Vienna at the close of the war, to take advantage of Austria's weakened condition, it was only by the utmost efforts of loyal citizens that the plans of these invaders were thwarted. The trained officials were able to detect the forged passports, to report the true nationality of the invaders, to locate the addresses at which they were converging, to discover when their printing presses started turning out literature, to seize this literature before it was distributed, and actually to arrest dozens of the leaders in single raids upon their headquarters. Austria's opinion of scientific crime detection is evident to all who visit the University of Vienna, where the crime museum is located and

where courses in crime detection are given. Judges, lawyers, and selected students take the courses.

The scientific crime detection laboratory is rapidly being introduced into our police departments. This enables the officer to attack in a field which is frequently not familiar to the criminal. If he were sufficiently educated to be familiar with the possibilities of the fully equipped scientific laboratory, he would abandon many of his attempts to profit from the labors of his fellow men. Universities and private schools are developing special courses for our peace officers. The public will not be disappointed in the returns from these investments.

HIGH FIDELITY ELECTRICAL REPRODUCTION

B. de F. BAILEY

The definition of high fidelity reproduction of speech and music is not a fixed one. It is, in fact, varied from year to year. Reproduction, which fifteen years ago was considered excellent, would, when viewed by present standards, be considered very poor and artificial.

There are a great many factors which determine the realism of the reproduction. The first factor is the frequency range of the equipment. By this is meant the ability to produce the lowest pitch and highest pitch notes of uniform intensity. The range covered by the human ear extends from twenty to twenty thousand vibrations per second approximately. It is presumed that, at some future time, systems will be built which can handle the entire range. At the present moment it has been found that a range of from forty to ten thousand is adequate and, except to a trained ear, would not be considered as any different from the full range.

The next point of great importance is that of noise added by the system. The maximum noise that can be tolerated in a system is about one thousandth of the power output of the desired reproduction. For really good results it is essential that extraneous noise introduced by the system be reduced to one millionth of the desired output. At the present time this can be met although not without considerable difficulty.

Another problem in reproducing systems is that of reverberation, or in other words the echoing sounds around an enclosed space. The reason for the difficulty of handling the problem of reverberation is that there are always two sources of reverberation in a reproducing system, namely, that of the original pickup point and that of the point at which the listener is situated. These two sources of reverberation give a result very different from that obtained by direct listening, and, as it is inevitable that there be some reverberation at both points, it is necessary to reduce the reverberation at each end of the system in an attempt to make the results similar to direct listening.

There are several other factors which influence the realism in the reproduction, but careful design will eliminate all of these

almost completely. With regard to the first condition, namely that of frequency range, there is an interesting feature. The so-called tone control on a modern radio set is a means of reducing the higher pitched sounds, thereby accentuating the lower pitch sounds. It is found in practice that the majority of listeners use this tone control to remove a great deal more of the higher pitch sounds than would be necessary for faithful reproduction of the original. Part of the reason for this is the fact that much of the noise added by the reproducing system is removed thereby, for example, static in a radio reproducing system. The writer, however, feels, although in all fairness it must be confessed that this is not a generally held view, that there is a further factor which enters into this use of the tone control. It is, apparently, an effort on the part of the listening public to make the music more enjoyable. This is the first opportunity that the public have ever had to change, of their own volition, the tone quality of music, and it is apparent that they prefer music of a more mellow variety with the higher pitch notes limited in volume.

This use of the tone control, therefore, appears to the writer to be, at any rate partially, a criticism of the musicians, and as such does not properly come within the scope of the communication engineer. From the standpoint of the communication engineer, his problem is to reproduce as faithfully as possible the original sounds at the reproducer. When this problem has been satisfactorily solved, it will be impossible for a listener to tell whether he is listening to the original source of music or the reproduction. In some systems, which have so far been built on an experimental basis, this has nearly been achieved.

A further interesting development in reproduction of music or speech is one which permits the reproduction of directional effects. For example, a listener in a concert hall hearing the music of a large symphony orchestra is able to separate the sounds of the individual instruments more completely because, with binaural hearing, we are able to concentrate on sound coming from one direction and ignore to a certain extent sounds coming from another direction. Most reproducing systems so far in use correspond to monaural or single ear hearing, in which, of course, there can be no great perception of direction from which the sound proceeds.

Recently systems have been developed which use two or more microphones to pick up the original sources of sound and, after transversing the reproducing system, the outputs of these several

microphones are connected to several loud speakers situated in the same relationship to each other and to the listener as were the original microphones at the pick-up point. In this way, listeners to the reproduced music can get a very fair idea as to the direction from which the sound is reaching them and the illusion is much more complete. The limitation of having a small point source of sound, which is quite serious, is thereby done away with. It is quite probable that some such system will very shortly be used in reproducing talking pictures.

In the various systems of electrical reproduction which exist today, such as radio, telephone, public address systems, gramophones and talking movies, most of the high fidelity requirements can be satisfactorily met. In the radio field, the biggest problem is not technical but financial and political. We have, at the present time, no adequate system of minimizing the number of stations on the air at once and, as a result, it is very difficult to prevent background noise or interruptions. Financially also, it is difficult to build broadcasting stations of high enough power completely to override static or other interference so that there will be no apparent background noise.

A COMPARISON OF THE GOLD DEPOSITS OF AUSTRALIA AND NORTH AMERICA

D. H. McLAUGHLIN

A Toronto audience may be assumed to be fairly familiar with the gold deposits of the world, for today this city is the acknowledged gold mining capital of our continent. Consequently, it perhaps seems rather bold for an outsider without exceptional qualifications to address you on the topic I have selected—namely, the gold deposits of Australia—and especially so since I cannot in any way claim to be an authority on them. A little over a year ago, however, I did have an opportunity to see many of the important mines of that continent under very expert guidance and I was so impressed with the extraordinary comparisons which could be made between the types of ores in that far part of the world and the ores with which we are familiar on our side of the ocean that I have felt this aspect of the subject might be worth bringing to the attention of a gold-minded community such as this.

So many things in Australia are strange and novel that the ore bodies there might properly have departed as far from the conventional standards of the Northern Hemisphere as the kangaroos and eucalyptus have in their respective domains. But such is not the case, for to a surprising degree the ore bodies exhibit forms, mineral associations, and geologic relationships which we have come to regard as characterstic on this continent. There is, fortunately, enough departure from uniformity to relieve them of any danger of boring a geologist—as a matter of fact, few ore bodies ever do that—but they do show a respect for the major concepts (or prejudices) which we have built up about ore deposits on this side of the Pacific that is very reassuring.

The miner from California, British Columbia, or Nova Scotia finds massive quartz reefs in Victoria and New South Wales that will remind him of faces of ore in his own drifts and crosscuts; and the geologist from Ontario will experience a corresponding feeling of being on familiar ground, when he visits the mines in the pre-Cambrian rocks at Kalgoorlie or in other parts of Western Australia. Deposits comparable to the gold-silver ores of Mexico, Nevada, and elsewhere in the relatively recent volcanic rocks of the

North American Cordillera, however, are not found on the mainland, but, on his way to Australia, the miner or geologist can easily see deposits of this sort if he will stop to visit the newly discovered Tavua gold district on Fiji or the better known gold-silver mines on the North Island of New Zealand. So, even though we are dealing with a portion of the crust almost at our antipodes, we find the major types of gold deposits, as we know them here, reproduced in much the same way, similar in mineralogy, in rock associations, in structure, and even in geologic age, if we are not too exacting as to precise correlations.

The similarities between the gold region in the western foothills of the Sierra Nevada and the gold fields of New South Wales and Victoria are so striking that a few months in California in 1850 were enough to convince Edward Hargraves that he could find gold in the country he had left—and he proceeded to go back to Australia for the expressed purpose of discovering gold, which he promptly did in a very matter of fact way.

In southeastern Australia, as in California, an amazing treasure of easily recovered alluvial gold was found. The coarse gold of the reefs, liberated from its matrix of slate and quartz during the long weathering and erosion of the region, was concentrated along the streams in such quantities that, in the first few years, an immense quantity of gold was won by the simplest of all metallurgical processes, the pan and other washing devices that can be operated by hand. Indeed, in both cases the actual discovery of gold seems less remarkable than the length of time which this conspicuous and highly prized metal remained unnoticed after the initial exploration of the region. Both were rich in poor-man's gold, and as soon as the dramatically-timed news of the finding of gold nuggets spread, the adventurous of the world flocked to them in numbers which almost obliterated the quiet agricultural population of Spanish California and submerged the small settlements of Australia beneath a wave of more competent and aggressive men. The quality and spirit of these pioneers transformed the life of their respective new countries and can still be seen in many characteristics of the population which fills these lands today.

As the easily won gold in the gravels of the present streams became exhausted, both in California and in Victoria, new stores of wealth were found in ancient stream beds buried beneath later rocks. In California, these ancient channels were found high on the sides of the deep canyons of the Sierra; in Victoria, they were

traced beneath broad lava flows and silts which still filled the old valleys. From both, new riches were won; and, in each country, great stores of gold still remained left behind when mining or other difficulties checked their exploitation.

Even during the earliest years, while a host of miners were washing the gravels, a group of wiser prospectors seeking the source of the gold had located the quartz veins along the Mother Lode of California and had discovered the conspicuous reefs of Bendigo, Castlemaine, Ballarat and many other districts in southeastern Australia. In part under the practical guidance of men from Cornwall, underground mining was started and, in the course of a decade, became the major activity of the two regions.

In order to appreciate the remarkable similarity between these two great gold regions, I must give you a brief outline of their geologic history. In the gold fields of southeastern Australia, the prevailing rocks are sandstones and shales—or quartzites and slates—with abundant fossils that indicate early Paleozoic ages—Cambrian, Ordovician, Silurian and Devonian. The beds, orginally flat-lying, are now sharply bent into arches and troughs with more or less northerly trend, like a series of great waves if the form of an individual layer could be exposed by peelng off the overlying strata. At intervals, the folded bedded rocks are interrupted by granitic bodies—crosscutting masses formed by crystallization of molten siliceous material (magma)—which had worked its way upward, engulfing and thrusting aside the rocks in its path. The magma probably failed to reach the surface, as it was at that period, and finally crystallized and solidified while still beneath a thick cover of rock. According to the prevailing theory, the gold, originally dispersed throughout a mass of this molten material, was concentrated in the portion that remained liquid the longest as the rock minerals separated from the melt, and was finally carried outward and upward as the residual solutions were expelled along channelways afforded by cracks and fractures in the adjacent rocks, where it was finally deposited with quartz and other minerals in the veins and reefs which we see today.

Change the sediments from early Paleozoic to Triassic and Jurassic, and allow the granitic rock to occur in bodies of greater size at a somewhat later age, and the same description holds for the major deposits of California, British Columbia and southeastern Alaska.

Even a closer analogy exists between the two regions in their later history. In each, the gold-quartz deposits were formed at fairly great depths and have been exposed by long continued erosion. By middle Tertiary time—some million years ago—both regions had been reduced to low rolling topography, with open valleys and well graded streams. The gold in the lodes on both continents is characteristically coarse and, when liberated from its matrix of quartz or mineralized wall rock by long weathering, it was in ideal form for concentration in the rivers which washed the region. For long periods, the streams maintained just the proper balance between scour and fill to form beds and bars of well-sorted gravel—mostly white quartz pebbles—abundant enough but not too abundant for the gold to accumulate in pay streaks of extraordinary richness.

This peaceful condition in the middle Tertiary was rudely interrupted on both sides of the Pacific by volcanic outbursts—not, of course, precisely at the same time but, at least, in fairly recent periods that correspond in a general way, geologically speaking. The earlier streams and their auriferous gravels were buried beneath some hundreds of feet of volcanic detritus and flows. Broad areas between valleys remained free from the volcanic rocks in Victoria but in California only the highest ridges survived.

From this point on, however, the similarity in geologic history ceases. In California, the lava buried landscape was tilted, as the block which now forms the Sierra Nevada range took shape, and deeply eroded by torrential mountain streams which raced down the long slope to the west. The rejuvenated rivers cut through the lavas, and even entrenched themselves deeply in spectacular gorges in the underlying bedrock—the Juratrias slate and granite which contain the gold quartz veins. In places, they cut across the courses of the old channels, which were left exposed as gravel banks beneath lava caps high on the sides of the abrupt present canyons. There they have been worked in open cuts where the overburden is small or through tunnels beneath the ridges where they are too deeply buried.

In Victoria, on the other hand, the country remained low and a situation considerably less favorable for the miner resulted. After the lava floods smoothed out the topography, through leaving broad areas of the older rocks uncovered along the divides, the region was slightly disturbed but in ways which caused depression and retardation of flow rather than rejuvenation. The present streams, des-

cending through their original valleys in their upper portion, encountered the lava flows and were forced to run out over them in fortuitous courses on the new broader valley floor. The gold-gravels, however, were found to continue under the lava, as the miners followed the rich placers downstream. To work them, shafts had to be sunk through recent valley fill and through the lava. At first they were shallow, but with increasing distance downstream they became deeper, until in certain of the lowest mines they reached depths of 600 feet.

The problem of mining these deep gravels in Victoria is far more difficult than in California, where drainage adits from the canyons could be driven. The gravels are still loose and open-textured and, consequently, are still channelways along which water can flow in great quantity. Before they can be mined, they must be drained. In the successful technique that was developd, a shaft is put down on the margin of the channel to a point far enough in the tight bed rock to allow crosscuts to be driven beneath the deepest part of the gravel in the particular property. Laterals are then extended close to the centre of the lead, as these old channels are called, and the water in the loose overlying gravel drained through bore-holes driven upwards to tap the channel. After the flow decreases to a safe minimum over an area large enough for mining—and not until then—raises are put up and the lower gold bearing portion of the gravel (and a foot or so of the bed rock) is mined in a series of small panels held temporarily on short posts.

Both in California and in Victoria, the quantity of gold still concealed in these ancient stream loeds is undoubtedly enormous. Some it may still be recovered by hydraulic mining in California, but in Victoria, underground mining is the only possible means. This, unfortunately, demands a large investment in plant and in exploitation before positive assurance can be given that the gold content in any given lead is high enough to yield adequate returns above the necessarily high cost resulting from heavy pumping and difficult mining conditions.

With the revaluation of gold, a number of bold attempts are being made to work the deep leads of Victoria and there is fair prospect that, with improved pumping and other technique, another period of local mining prosperity may result.

So far, I have said little about the original quartz veins or reefs from which the placer gold, ancient and modern, was derived. In

Victoria and in New South Wales, the centres of mineralization are scattered rather irregularly over the map and do not conform to a broad lineal pattern which is so distinctive a feature of western North America from the Mother Lode of California to the Juneau gold belt of Alaska. Their distribution in Australia, in a general way, conforms to the distribution of intrusive granitic rocks, but, on the smaller scale that is of more significance to the miner, the grain of the country is the dominant factor and brings about rather definite and useful alignments.

In the individual districts in Victoria, the ore bodies occur in forms determined, for the most part, by the patterns assumed by fractures imposed on the rocks and their pre-existing structures. In the highly folded Ordovician slates and quartzites at Bendigo, the gold deposits, to a remarkable degree, are distributed along the axes of arches (or anticlines, to use the technical term.) Zones two hundred feet wide along the crest of more than twenty-two of these folds in the old sediments are marked by recurrent quartz reefs, as narrow veins on breaks parrallel to the bedding, and as lodes made up of numerous short transverse lenses of quartz on the flanks of the folds, or as saddle-shaped bodies near their crests. These rather unusual shapes result simply from the way the already folded layers of rock broke under later stresses, and, by so breaking, made possible the penetration of the quartz-forming and gold-depositing solutions.

The individual quartz reefs or groups of quartz lenses on the flanks constitute mining units which have great extent longitudinally along the structure but are of limited dimensions across the fold or down the flanks. Bold exploitation through barren rock must be undertaken to find successively deeper reefs; but in this work, the axis of the fold and the nature of the faulting affords a good measure of guidance. Much of the quartz is barren, but spectacular ore shoots of bonanza grade have been encountered with sufficient frequency, in the course of systematic development in the various mines, to have made the record of profits over the fifty years of the active life of the district a thoroughly satisfactory one.

To the student of ore deposits, Bendigo presents no problem of classification in spite of its structural peculiarities. The mineralization closely resembles that of the Mother Lode and Bridge River—typical mesothermal deposits, to use technical jargon for a moment. The closest analogy to Bendigo on this continent, however, is found in the numerous quartz reefs in folded early Paleozoic

slates and sandstone in Nova Scotia. Unfortunately, however, the Nova Scotia deposits fail to match the richness of the Australian reefs, but apart from this minor point, quite trifling from a scientific standpoint, they exhibit a remarkable similarity.

In a somewhat different way, a comparison may be made between the Bendigo ore bodies and the deposits near Juneau, though, in the latter, minerals are encountered that are indicative of formation at somewhat higher temperatures. The Bendigo lines of reef may be regarded as broad lodes which, with somewhat closer spacing of the quartz reefs, might have been capable of mining by some bulk low cost method, breaking and removing the entire mass of rock and quartz, as at the Alaska Juneau Mine. Instead, the individual reefs at Bendigo are large enough and rich enough for successful selective mining, whereas, at the Alaska Juneau, the individual quartz seams, though locally of fair richness, are too small for such exploitation but are sufficiently abundant to make it profitable to mine wide bands in a wholesale way. To compare a bonanza district such as Bendigo with the lowest grade gold mine in the world may seem rather far-fetched, but the difference is chiefly one of size and spacing of the quartz bodies. The quartz veins, lenses, and even small saddles in the folded slates at the Alaska Juneau make an ore body that closely resembles certain aspects of the Bendigo lines of reef.

But here in Ontario I must not dwell too long on these deposits of the Pacific Coast type, but turn to Western Australia where gold ores extraordinarily like those of the Canadian shield are found in the vast area of pre-Cambrian rocks of that state.

As far as the nature of the landscape is concerned, no two areas of low relief could be much more unlike than Western Australia and the north woods of eastern Canada. Instead of polished glaciated outcrops rising above muskeg or broad plains of clay in a densely forested country with rivers and lakes at close intervals, one sees an area of almost comparable extent without running streams, with broad, flat, salt lake beds or playas, with flat-topped mesas capped with deep layers of red laterite, and miles upon miles of sparse eucalyptus or mulga bush, deceivingly green when seen from some slight elevation but masking a condition of aridity that makes exploration away from the lines of travel dangerous for those unskilled in desert travel. The technique of prospecting in the two regions is totally different. In Canada, the waterways have made it easy to penetrate into exceedingly remote country. In Western Austra-

lia, most of the land is flat enough for wheel vehicles, but the lack of water creates difficulties of unusual sort. Salt beds, desert washes, and deeper oxidation obscure the surface instead of lakes and muskeg. The outcrops in Canada are easier to read but harder to find. Each region has its own advantages but each imposes difficulties which prevent over-rapid development. Even from short acquaintance, a geologist or miner cannot help gaining the feeling that both regions possess immense and still untested possibilities. In spite of the acclerated rate of exploration, with outboard motors in Canada and motor cars in Australia, and by airplanes in both regions, the degree of concealment is such that the rate of discovery will necessarily be kept fairly slow—a condition that perhaps makes for healthy growth and long life of a national mining industry, which is much to be preferred to the excessively rapid skimming of the cream of natural resources that has occurred in other more easily prospected regions.

Beneath the surface, however, all sense of being in a strange land is lost. The Western Australia greenstones are an assemblage of lava flows—some even with pillow tops— that would be casually called Keewatin without much argument if encountered in a mining district in the Canadian shield. The "jasper bars" of Australia closely resemble our banded iron formations, and as faithfully serve as markers of structural horizons. The various infolded sediments find their counterparts in the Canadian shield; and their correlation between districts lead to the same controversies and uncertainties. Granitic rocks are more abundant in the Australian pre-Cambrian but by no means enough work has been done on them to establish their sequence with anything like the degree this has or can be done in Canada; but in a very broad sense, a similarity exists between certain rather late, relatively unsheared intrusives in Western Australia and the granitic rocks and porphyries termed Algoman in this country, which might be reassuring to geologists who regard the latter as the source of the gold in so many districts in Canada.

I am not, of course, suggesting that correlations of such definite character can be made from one side of the world to the other. We all know that in the pre-Cambrian correlations even between districts a few tens of miles apart are all too uncertain. But the similarities, when considered on a very broad scale, are rather remarkable and a geologist, familiar with the Canadian shield, would find himself dealing with very similar rocks and structures and in

the midst of the same types of problems, if he transferred his activities to Western Australia.

Time does not permit a more detailed discussion, but I should like to say just a word about Kalgoorlie, the greatest of the gold districts of Western Australia, before I close. In brief, Kalgoorlie might be compared with the Porcupine district, as far as rocks and structures are concerned, and with Kirkland Lake, with regard to ores and mineralogy. The "calc schist" of Kalgoorlie closely resembles certain pillow lavas and associated flows in the Keewatin volcanics of Porcupine; interbedded carbonaceous slates occur in both districts and a pitching syncline can be deciphered in Kalgoorlie, though even more complicated in detail than in the Porcupine district. The lodes themselves, however, in no way resemble the conspicuous quarts veins and lenses of the Hollinger, McIntyre and Dome Mines, but find their analogues in the bands of quartz seams and altered rock with gold and tellurides that constitutes the ore at Kirkland Lake. Of course, the comparison should not be pushed too far. Kirkland Lake, great as it is, has yet to produce an Oroya ore shoot—a flatly inclined, pipe-like body of ore, 4,000 feet long, from which 2,000,000 ounces of Kalgoorlie's total gold was recovered. On the other hand, the lodes at Kirkland Lake have shown a regularity and a persistence in depth which is rare in Kalgoorlie. It is still too early to predict which will be the greater of the two camps, when exploration is completed and the final balances can be compared. Kalgoorlie had the earlier start and the more spectacular early history; it is now far surpassed in annual production by each of the two major Canadian districts. Whether or not Porcupine and Kirkland Lake will ever be able to match Kalgoorie's magnificent production of over 21,000,000 ounces is still problematical, for even though the annual output of each of the Canadian districts is now much greater, the older Australian camp is still active and by no means ready to rest on its past record.

Even in the risky matter of predictions with regard to the future of gold mining, a certain similarity exists between the two continents. The current revival of output of lode mines in south-eastern Australia and on our Pacific coast is likely to be merely a local peak on a declining curve. Some new mines will be developed; some old ones will be revived; but the chances for major discoveries seem poor. On each continent, however, a tremendous treasure of gold is undoubtedly still concealed in the Tertiary channels but under conditions too unfavourable for the prospector or

miner to offer much hope for successful operations on a scale likely to attract wide attention.

In the extensive "shield" areas of ancient rocks of both continents, however, the curve of discovery and production may reach even new major peaks, at least in Canada, where it is high and still climbing. In Western Australia, the slump from a spectacular maximum in the early part of the century was an extreme one. District after district died in the war decade, which, for gold-mining, was a period of extreme difficulty. Many mines, active and profitable twenty-five years ago, are now marked only by high dumps of tailings and decaying poppet-legs (to use the Australian term for parts of a head-frame). At one famous old mine, the Great Fingal, a tall rusty steel structure stands alone in the desert beside a drifting pile of sand from a vanished cyanide plant, with little else to mark the former existence of a mine which produced $20,000,000; the sites of other, less imposing, operations are, in some cases, marked only by a few pepper trees, brought in by the miners thirty years or so ago to relieve the monotony of the desert bush. When one recalls, however, that in this extensive area of ancient rocks and deep-seated deposits mines in only three districts have yet been carried to depths greater than 2000 feet, it seems most reasonable to expect that eventually bolder exploration will be undertaken in Western Australia, and a second harvest of gold—probably not equal to the first but still not to be scorned—may yet be won from the deeper levels or from concealed areas, when our techniques of ore-finding have advanced beyond their present fumbling stages.

THE SCIENCE OF SOUND

WALTER J. HODGE

We live in a world of sound; yet, in spite of its vital importance to every day existence, sound rarely enters into our conscious thinking. We depend on it for communication by speech, for entertainment, danger signals as an aid to navigation through air and on sea. In the average person's existence there is never a moment, day or night, when his ears are not recording sounds of one kind or another. But because so little is commonly known of the subject, the air is filled with sound that is not only a constant inconvenience, but which works positive harm to all who must suffer its attacks.

It is here the intention to sketch briefly some of the basic principles of sound control, and to show how a knowledge of these principles may be applied to problems in every day life. The subject of sound and vibration is one of the oldest branches of science, extending back to the earliest of our modern scientists, Galileo and Newton. But until recent years, this subject has rarely met discussion outside the lecture hall and laboratory. That we have so recently awakened to the importance of sound and sound control is partly due to the whirlwind spread of the art of sound reproduction, and is due even more to the clanking, screaming uproar of a berserk machine age.

Wherever and whenever a vibration occurs, be it in the string of a piano or violin, a column of air in an organ pipe, or the diaphragm in a telephone ear piece, the stage is set for the creation of sound waves. Any vibrating object, in its motion, pushes to and fro on the air particles surrounding it on all sides. These air particles in turn disturb their more remote neighbors. By this interaction of the air particles, the original vibration spreads out in the form of a bubble of ever increasing size, and if the creative vibration persists, this bubble is folowed by similar bubbles, regularly spaced and moving hard on the heels of the first. As the bubbles grow very large, their walls will become so very thin they will finally melt into nothingness. So it is with the air vibrations which ultimately are spread over such vast areas as they move out and away from

* This lecture has appeared in Refrigerating Engineering for 1936 under the title "Sounds of Today."

their source that the reduced vibrations of the air particles become lost in the random motions of the air in general.

If by chance a human ear should be in the path of any of these swiftly expanding bubbles of air pressure, its infinitely delicate mechanism would telegraph to the brain the time of arrival and the intensity of each arriving pressure as it came, and the owner of the ear would derive from this an impression of the pitch and loudness of the sound. These pressure bubbles all expand outward at the same rate of approximately 1,100 ft./sec., called by us the "speed of sound." If they arrive at the ear with great frequency we say the resultant sound has a "high pitch." The measured distance between bubbles is known as the "wave length" of the sound considered. If the pressure bubbles arrive less frequently, the distances between them (their wave lengths) are correspondingly greater or longer, and their frequency or pitch is obviously lower. If the ear should be close to the source, the pressure bubbles will be smaller and more concentrated. At a distance from the source, they may be weakened to ineffectiveness. The ear, functioning as an exquisite pressure guage, interprets these pressure bubbles in loudness values. Hence we see the basis of human pitch and loudness judgments in sound.

However, the kinds of sound just discussed occur very rarely as natural phenomena. The sound waves set up by the whistle, an organ pipe or the voice of a friend, are never a simple set of vibrations such as those just considered. Rather they are a composite of many simultaneously-generated vibrations. What we know as the "pitch" of such sound is determined by the pitch of the lowest frequency vibration present. The other vibrations which accompany this lowest frequency or "fundamental" vibration are known as "'overtones," or "harmonics." It is because the human ear is without equal in detecting and analyzing these overtones in sounds that we are so keenly aware of the differences in human voices; that we differentiate between different musical instruments even to the extent of preferring a particular violin to another seemingly identical. Such a composite wave as we have here discussed is shown, with the components going to make it up in Fig. 1. If the vibration drawn here in graph form were set up in the air, the ear would pronounce the resultant sound to be that of a violin. Conversely, apparatus is available to draw such a record as this from sound existing in the air, and if a violin tone were to be so recorded, the complex waves of Fig. 1 would result.

It is thus evident that any musical tone, that is, any sound of definite pitch, is the resultant of one or more simple and uniform vibrations, and the the amplitudes (or intensities) and frequencies of these vibrations determine the sound intensity and quality of the resulting complex vibration. While the ear is without an equal in judging the quality of sound, it is not an accurate judge of frequency or intensity **per se.** Intensity largely determines sound loudness, and to provide an accurate measurement of this characteristic, an

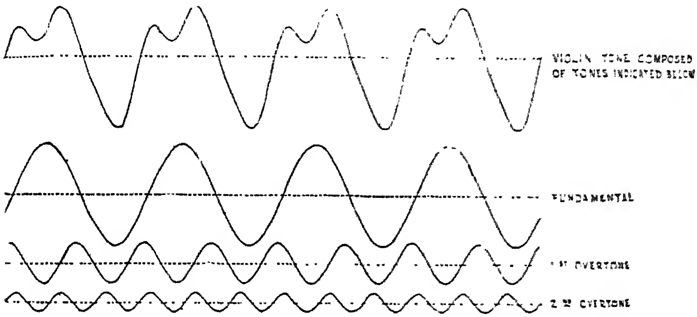

FIG. 1. SOUND WAVES OF A VIBRATING VIOLIN STRING.

electrical apparatus known as a sound or acoustimeter is usually employed. Indeed, a sound meter is to acoustics what a thermometer is to heat.

ORIGINS OF ACOUSTICAL ENGINEERING

Up to this point we have been discussing sound entirely from the viewpoint of the scientist. But in this modern world, sound forces its way into everyone's consciousness. Nearly every outstanding invention of modern times has left a wake of new noises—the radio, automobile, steam engine, trolley-car, electric refrigerator, typewriter, sewing machine, printing press—the list is endless. About the only really noiseless invention of modern times is the electric light; and this does not consider at all those inventions specifically intended to make noise—automobile horns, sirens, doorbells down to alarm clocks.

Thus noise in its countless aspects is continually raising problems. For example: How can employers capitalize on the benefits of modern office machinery without compelling their employees to work under conditions of distressing noise? Again, how can residence interiors be protected from exterior street noises and from the various miscellaneous sounds that domestic equipment generates?

These and countless questions like them arise daily. They have called into being a new branch of engineering—acoustical engineering. Originally the acoustical engineeer interested himself almost exclusively in the acoustical design of auditoria, but in recent years his activities have broadened to include many other sound problems. So rapid was the demand for and the growth of acoustical engineering that facts and theories of sound and vibration were frequently not available when demanded. Five or six years ago, when this need of information began to be acute, because of depression-reduced budgets the research laboratories of the engineering universities possessed neither facilities nor appropriations adequate for speedily penetrating the frontiers of practical acoustics. Several agencies, including my company, recognized the need of further research. As a result we now have one of the outstanding acoustical laboratories at our research laboratories at Manville, N. J. During the past five years of its existence, it has produced valuable and revolutionary contributions to the science of sound and vibration control.

THE DECIBEL EXPLAINED

Noise is aptly defined as "undesired sound." At one time all sounds not pleasing were termed noises, but this definition is open to exception. Even the cadence of a Wayne King waltz can be noise if it emanates from a neighbor's radio at three o'clock in the morning. Likewise the sound of rushing water would not be called noise by a thirsty individual to whom it promised a drink.

In an effort to compare and classify noises, a special measuring technique has been developed, built around that unit with the strange name—the Decibel. A one decibel change in sound intensity corresponds roughly to the slightest change in loudness that can be distinguished by the human ear. As a matter of fact, the actual derivation of the decibel is no more important to the average man than is the derivation of the degree Fahrenheit. If we wish to describe the hotness or coldness of our surroundings, we say "The temperature is 80°," or "The Thermometer reads 20° out-of-doors," and other persons know from their own experience what we mean. When the decibel scale becomes more widely known and understood, it will be as informative as the temperature scale is when we say, "The noise level is 80 decibels" or "20 decibels," as the case may be. Briefly reviewing the history of the decibel, we find it is one-tenth of a Bel (a unit named by the telephone engineers

after Alexander Graham Bell), and signifying in telephony a certain increase or decrease in sound or electrical intensity. Essentially it represents a ratio between two quantities. In sound it is used to indicate the ratio of energy existing between any given sound and the faintest sound that the ear can hear.

The decibel thus stands to sound in somewhat the same relationship that the degree Fahrenheit stands to heat, where, for example, we would denote the amount of physical discomfort to be experienced in a certain room by the number of "degrees Fahrenheit" existing between the temperature of that room and another reference room in which one could remain in absolute comfort. Suppose 70° represented this comfortable temperature, then another room of 100° would certainly be classed as uncomfortable, and 30° would signify the extent to which it was so. Assume the temperature is now reduced from 100° to 90°. It is only a 10° reduction, but it goes without saying that this represents a tremendous increase in comfort. Just so does it work out in the case of sound. A 50db. level is that of a quiet office; 60 db. that of a noisy office. If the 60 db. level be reduced to 50 db., the actual reduction is only 10 db., but the increase in physical comfort and well-being is enormous. As you walk down a city street and pass by a riveting machine at work, you are conscious of a terrific din. If the machine suddenly stops, the surroundings seem by contrast almost quiet. Yet here the actual sound level has been reduced only about 10 db., from approximately 90 db. to 80 db. It is good fortune indeed that sound-absorbing materials of high efficiency, properly installed, are very frequenty capable of quieting noisy rooms and offices by an easily calculable amount—usually as much as 10db.

Table 1. How Noise is Measured

Energy units	*Decibels*	*Sound source*
10,000,000,000,000	130	Threshold of painful sound
1,000,000,000,000	120	Artillery gunfire
100,000,000,000	110	In airplane cabin
10,000,000,000	100	In subway car
1,000,000,000	90	Average auto horn
100,000,000	80	Tabulating machine room
10,000,000	70	Average stenographic office
1,000,000	60	Average general office
100,000	50	Average quiet office
10,000	40	Average residence
1,000	30	Quiet farmhouse
100	20	Underground vault
10	10	One's own heartbeat
1	0	Absolute stillness

Table 1 shows what is often called a "noise thermometer." it is probable that a very few years will see the ideas here depicted just as commonly known as are winter and summer temperatures on the thermometers that hang ouside our windows. Sound-absorbing materials are available that are capable of blotting out as much as 85% of the sound striking them. The materials are rated according to their effectiveness in this performance. In a noisy room, it is plain that all the sound passing out through an open window is henceforth lost and no longer contributes to the din and clatter of the room. In this case, the sound is reduced by escape. (It is of course assumed that no outside sound enters the room through the open window, i.e., that the noisy room be situated in a quiet country place). It is possible and economical today to apply highly efficient sound-absorbing materials decoratively to the wall and ceiling surface of a noisy room with such effect that noise reductions of 5 to 15 db., depending on conditions, can be attained. Such materials convert almost as much sound energy into heat as an open window of equivalent area would permit to escape.

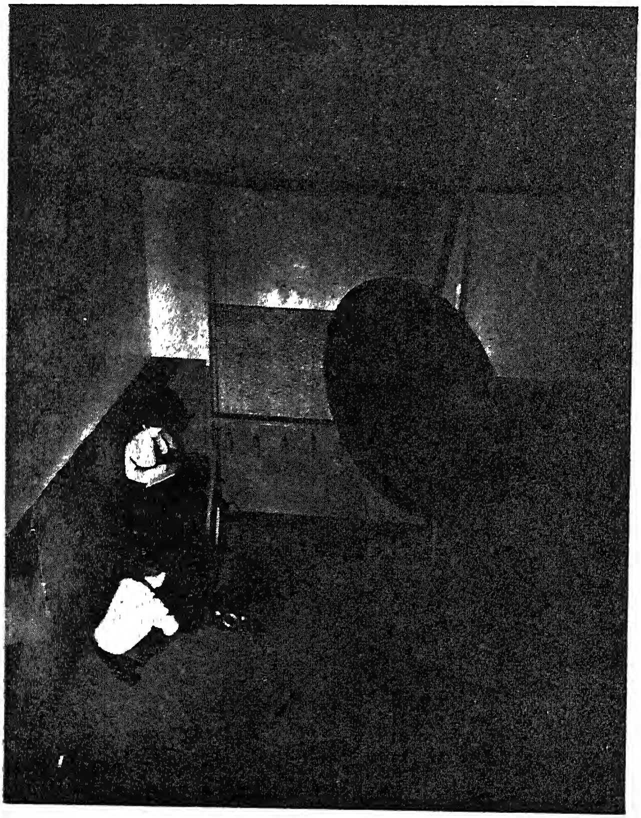

FIG. 2. REVERBERATION ROOM IN LABORATORY, SHOWING OPERATORS MAKING ADJUSTMENTS AFTER TESTS.

Properly selected, such sound-absorbent materials are highly light-reflecting, fireproof, salvageable in tenant change and easily maintained, both aesthetically and hygienically.

When it is necessary to isolate a noisy space from a quiet one (e.g., a noisy general office from a quiet private office) highly efficient sound isolation constructions are already available and proven by use. When vibrating machinery offends, vibration isolation will be found to be economical, practical and highly successful in result. Much of the knowledge making all this possible had its source in the laboratories already mentioned.

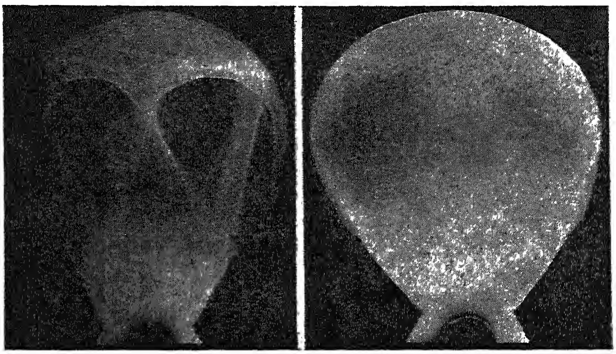

FIG. 3. SOUND WAVE ACTION IN UNTREATED (LEFT) AND TREATED (RIGHT) WALLS.

Fig. 3 presents an interesting example of sound-absorption as applied to theatre or auditorium acoustics. The photo to the left, before acoustical treatment was installed, shows how sound was unevenly distributed. An echo (sound delayed by too much reflection from wall and ceiling surfaces) was heard where the sound waves focussed in the center rear, and comparatively quiet spots existed to either side of that point. The photo to the right shows that after corrective measures were applied, sound was evenly distributed throughout the theatre, and echoes were eliminated. A companion to echo is the effect known as reverberation. It is really a multitude of echoes so closely spaced as to defy segregation whose net effect is to blur speech and music into chaos of noise. The effects of reverberation can be experienced even out-of-doors, as when a rifle is fired in a mountain ravine. The sound reverberates noticeably for a few seconds, due to reflections to-and-fro from the walls of the ravine. Finally, it either escapes from the ravine or is absorbed by the bushes, trees, and surroundings. Obviously, this effect of reverberation is present in the canyon-like streets of our large cities and contributes to the high noise levels existing there.

In completely enclosed spaces, such as rooms, there is usually no exit the sound can take, and so it continues to rebound from wall to wall to ceiling, until absorbed by especially constructed materials. Unless this conversion is accomplished by sufficient and efficient material, succeeding sounds collide with sounds not yet absorbed, and confusion results. Less spectacular than echo, reverberation is far more common, and fortunately, can be overcome, through application of modern sound-absorbing materials, properly situated.

The harm which noise does to the human mechanism is by no means a matter of guess-work. One set of experiments showed that typists used 19% more energy working under noisy conditions and lost more than 4% in speed. And here is something interesting from the common viewpoint of all businesses—efficiency and economy: An installation of quieting treatment in a telephone room of the Western Union Company reduced the number of errors made in handling messages 42%; a net saving of 3% in the cost of each message resulted. In another installation in the bookkeeping department of a large department store a reduction in errors of 24½% was effected.

In the laboratory have been discovered principles of new and revealing importance regarding sound. We know its cause and effects; its results when suppressed and when out of control. Great resources and engineering ability are now at hand to provide quiet for all who realize the need for it and will demand it. When the benefits of sound—**controlled**—are realized, then noise, the greatest scourge of modern times, will be doomed.

WOODS, WATERS, AND WILD LIFE

WILLIAM L. FINLEY

The lecture of the evening was delivered by Dr. William L. Finley of Portland, Oregon, an outstanding leader in the movement for the conservation of American wild life. The lecturer developed his case for wild life conservation with the aid of five reels of absolutely unique motion pictures. The first of these dealt with the problems of conservation, which arise through the erection of motor roads through previously isolated territory, using Oregon roads and the sea fauna as examples. It dealt also with the relation of the preservation of the Pacific salmon, from the standpoint of the artificial barriers introduced to prevent their return to head waters to spawn, especially of the dams erected for power and irrigation purposes.

The second reel dealt with conservation problems and forest reserves; the third with the effects of constantly decreasing marsh lands and bird life; the fourth with decreasing water levels and water fowl; and the fifth with the sane utilization of the public domain, looking toward an effective compromise between conserving our resources and providing for the legitimate advances of the agrarian and commercial interests of the land.

HORMONES—THE CHEMICAL REGULATORS OF THE ANIMAL BODY.

G. F. MARIAN

Hormones may be defined as chemical substances elaborated by certain organs or tissues, which effect changes in other organs or tissues after being carried to the latter in the blood stream. Carbon dioxide, a product of muscular activity, may be described as a simple type of hormone. After violent exercise, the excess carbon dioxide in the blood stimulates the "respiratory centre," which in turn causes the respiraton rate to be increased, thereby bringing an extra supply of oxygen to the oxygen-thirsty muscles.

Our present knowledge of the chemical nature and mode of action of the hormones is largely a product of the last ten years. At least sixteen different hormones have been clearly recognised by physiological methods. Of this sixteen, seven have been prepared in a chemically pure form; of this seven, the exact constitution of five has been determined, and these five have been artificially prepared in the laboratory.

Two of these hormones, (thyroxine and adrenaline) may be considered to be derivatives of the amino acid tyrosine. The former is an iodine containing compound elaborated in the thyroid gland which is situated in the neck. Its function appears to be that of regulating the rate of metabolism or chemical activity in the body. In the absence of iodine from the diet, the thyroid gland is unable to synthesize this hormone, and, as a result of this, malfunction of the gland results. Adrenaline is prepared in the medullary or outer portion of the adrenal gland which is situated just above the kidney. It posesses the property of increasing the blood pressure, when injected into animals, and it appears to play an important part in regulating the utilization of sugar in the body. Both these hormones have been synthesized in the laboratory.

A large group of hormones are chemically related to the substance cholesterol. In common with the latter, these substances possess the cyclopentenophenanthrene skeleton. It is believed they may be formed in the body by the partial breakdown of cholesterol. These include the so-called "male hormone," which is elaborated in the testes and which is responsible for the development of the

characteristic secondary sexual characteristics in male animals; the oestrus-producing hormone, which is elaborated in the ovaries and which causes the periodic symptoms of heat or oestrus in female animals; progesterone, a hormone prepared in the corpus luteum which has important functions in the female during pregnancy; and the hormone of the adrenal cortex. The first three of these have been artificially prepared in the laboratory. Recent reports suggest that the last may also very shortly be synthesized.

The pituitary gland, situated at the base of the brain, appears to be the most important gland in the body. The anterior lobe of this gland elaborates at least seven distinct hormones. The activities of the sex glands, the thyroid gland, the parathyroid glands, and the adrenal cortex, are all controlled by specific hormones prepared in the anterior pituitary gland. Furthermore, this gland secretes a hormone which controls the growth of the whole body, and another which controls the secretory activity of the mammary glands. These hormones seem to be proteins or protein derivatives. The problem of their chemical constitution is therefore a difficult one. It is unlikely to be solved in the near future.

THE NATIONAL PARKS OF THE UNITED STATES

HAROLD C. BRYANT

It is now 65 years since America began building a park system. The beginnings are interesting, for we find that it was not a group of city dwellers longing for open spaces who first conceived the idea of a national park but some hardy pioneers of the State of Montana. Having heard great stories of the unusual hot springs and geysers to be found in what we now call the Yellowstone region, a group of men set out to investigate. They spent nearly four weeks traversing the area. They had ridden within 300 yards of Old Faithful when, for the first time, they saw the great geyser throw its hundreds of gallons of hot water high into the air. We can imagine their astonishment. Just before leaving, this group camped at the junction of the Madison and the Firehole Rivers. Around the campfire that night, they discussed the wonderful phenomena they had seen. At first, the consensus of opinion was that each one should go back to the Land Office and attempt to secure from the Government as much land as possible, in order that they might profit from mineral and other wealth that they might find. One man, however, Cornelius Hedges by name, expressed the opinion that it would be far better to set aside the area as a national park "for the benefit and enjoyment of the people." The idea finally prevailed and we now speak of this event as the birth of the national park idea in the United States. Eighteen years later, three other parks were added and the system continued to grow until, at the present time, we have 26 national parks, 73 national monuments, and numerous miscellaneous areas, all united in a great park system dedicated to the motto "for the benefit and enjoyment of the people."

Within the park system are many superlative scientific features. Starting with Yellowstone, we have an area which contains thousands of hot springs and hundreds of geysers. In fact, there is presented there the finest geyser system in the whole world. Nowhere else can be found a great geyser like Old Faithful which erupts with notable regularity. Many other geysers may be larger but they are not so dependable. One might wait for days to see the giant erupt, but every visitor is assured of a view of Old Faithful in action.

Undoubtedly, the thermic activity of Yellowstone results from hot rocks beneath the surface. No one yet knows what chemical action is involved.

Also presenting thermic activity, there are several recently active and still active volcanoes within the American park system. Of particular note is the great Kilauea in Hawaii National Park. When its lake of fire gives a demonstration there is no finer chance to see molten rock and observe its actions. The nearby Mauna Loa periodically gives fine examples of lava flows. In Lassen Volcanic National Park we find Lassen Peak, which, in 1915, gave a demonstration that brought many scientists to examine its evidences of activity. One area was swept clear of a great forest by a steam blast down the side of the mountain. Another area was buried thirty feet deep in mud. The evidence of waning activity is visible and, in addition, there are hot springs and many gas vents.

Volcanoes may grow in to great mountains. Alternate eruptions of lava and ash may build cones thousands of feet in height. However, many of the scenic mountain regions have been created by a folding or faulting of the earth's crust. Grand Teton National Park presents a magnificent mountain range with a steep escarpment to the east and a gentle slope to the west, indicating that the range was formed by the tilting of a great block of the earth's crust. In Glacier National Park, we have another mountain range, part of the Rockies, where a segment has been thrust out over the plain, presenting one of the most notable examples of an over-thrust. Scientists estimate that the mountains have been pushed out over the plain at least fifteen miles. Here is a place where we may find, at the fault line, older rocks superimposed on top of younger ones. We are, of course, accustomed to expect the youngest rock on top.

Mountains are no sooner uplifted than nature begins tearing them down. The greatest agent in the destruction of mountains is erosion. There are numerous wonderful examples of what water and ice erosion may accomplish. In the Grand Canyon. we find that the Colorado River, given good tools with which to work in the form of plenty of sediment and a steep gradient, has cut a mile-deep canyon in whose bottom are exposed some of the oldest rocks known —those of the Archean era. In Zion National Park we can see another great water-cut canyon of extreme beauty. Excavated through red and white sandstones and limestones, this canyon presents a majesty and a color picture found nowhere else.

In Bryce Canyon National Park we find presented a different type of erosion. Here drops of rain and windblown sand have carved fantastic pinnacles, towers and walls of intricate design and rare beauty.

Water may also produce such strange configurations as seen in the Rainbow Bridge of southern Utah, probably the largest natural bridge in the world. Its arch is so high and so wide that the Capitol Building in Washington could easily be placed beneath its spread.

When water meets certain conditions beneath the ground, there may result more formations of unusual beauty. Near Carlsbad, New Mexico, water, forcing its way through shattered limestones, has created the greatest series of limestone caverns in the world. More than 30 miles of them have already been explored and no one knows how many more miles of underground caverns there are. Stalactites and stalagmites are found in profusion and visitors to the park receive a thrill which they never forget. The cave contains three levels. Visitors are taken to see only about seven miles of the top level, which is approximately 750 feet below the surface. The lower levels, which are still more beautiful, are left undisturbed.

Glaciers constitute another agent of erosion. One park has been named "Glacier" because of the 60 ice masses that it contains. The greatest display in the United States proper, however, is to be found in Mount Rainier National Park. Radiating from its summit like an octopus, the 28 glaciers cover an area of more than 40 square miles. Rock debris left by the melting ice forms great moraines from which one may walk on to the surface of the ice. Here, among the yawning crevices, is an opportunity to get a first-hand acquaintance with a real moving glacier which continues carving a great canyon in the mountain side. A developing glacier which extends its icy mass on to the surrounding plain may be seen at Mount McKinley National Park, Alaska. Still another type with its melting face in an ocean bay is to be found in the Glacier Bay National Monument, also in Alaska.

Thus far we have been dealing with examples of geological processes. Let us now turn to areas which present biological features.

There are many superlative forests within the national parks, notable examples of which are the magnificent Douglas fir, Sitka spruce, western red cedar and western hemlock forests of the Mount Olympus region; the Douglas fir, hemlock and western red cedar forests of Mount Rainier; the ponderosa pine forests of the North Rim of Grand Canyon, with their beautful intermingled golden

aspen; and the wonderful sugar pine and ponderosa pine forests of the western slopes of the Sierra Nevada in Yosemite, General Grant and Sequoia National Parks, California. Of special interest in these last three parks are the groves of giant Sequoias or Big Trees (Sequoia gigantea), probably representing the largest and oldest specimens of life in the world today. While the genus Sequoia was at one time, ages ago, distributed over a large part of the earth's surface, it is today restricted to northern California and the southwest corner of Oregon, and is represented by two species, one of which, Sequoia sempervirens or Redwood, is found only along or close to the coast. This species is represented in the national park system in Muir Woods National Monument, readily accessible from San Francisco. The Redwood reaches a maximum height of 364 feet, which is probably the tallest existing tree on record. The other species, Sequoia gigantea or Big Tree, is limited to the Sierra Nevada where it is found in groves at elevations of from 5,000 to 8,000 feet above sea-level. This species reaches a height of from 275 to 320 feet, and a maximum diameter of 35 feet. Counts of the annual growth rings on specimens of this species indicate an age of from 3,000 to 4,000 years for some of the oldest of these Big Trees. The extraordinarily thick and fire-resistant bark of the Sequoias, both Redwoods and Big Trees, affords greater protection against forest fires than is the lot of other trees, and neither species is greatly affected by insect attacks or fungi, possibly due to the presence of tannin. Probably in these qualities of resistance to fire, insects and fungi lies the secret of the great age and great size of the Sequoias.

To me, the trees of timberline appeal strongly. They are to be found in most of the national parks. Trees which live at high elevations must overcome great handicaps to exist. Snow covers them deeply in winter, great storms break off their branches; their roots must often find a foothold in the crevices of solid rock. A sense of reverence pervades us as we study their struggle for existence.

Some of the national parks are noted for their wild flower displays. Strange as it may seem, some of these parks which have the shortest growing season, because they are covered with heavy snows until late in spring, afford the greatest display. Mount Rainer and Glacier National Parks present a marvelous display of color during the summer season. Probably the abundant water supply as well as the short growing season combine to furnish a massed effect. Three lilies come to mind as being of special inter-

est in the western national parks, the so-called glacierlily or fawn lily (genus Grythronium), abundant in the northern parks, and the Mariposa-lily (Calochortus) and Washington lily (Lilium Washingtonianum) of the California parks. One might pick out other notable flowers sufficiently unusual to attract the eye.

National parks are complete sanctuaries for all forms of life. Consequently, the place to see animals is a great national park like Yellowstone, where herds of elk, antelope and buffalo present a picture of the pioneer days when these animals were to be found in many areas. In making the loop trip in Yellowstone, I have seen three of the bull moose, which animals are becoming more abundant in both Yellowstone and Glacier National Parks. Most people who go to the western parks have plenty of opportunity to see bears. In Yellowstone, "hold-up" bears sometimes approach machines begging for something to eat. In fact, some of them have appeared too tame and many a trusting individual has had to go to the hospital, for bears are still wild and not to be trusted. Hence, a rule forbids visitors to feed the bears. Although the grizzly bear is extinct in most western States, a census shows about 286 grizzly bears in Yellowstone National Park alone. In attempting to give the visitor a chance to see these rare animals, they are invited to a feeding platform covered with scraps from the hotel tables and kitchens. I have myself counted 37 grizzly bears in an evening at one of these feeding stations but that record has long been displaced by a record of some 67. Certainly, nowhere else in the world can one obtain such an intimate view of grizzly bears of every size and color.

The millions of bats which leave the mouth of Carlsbad Caverns every summer evening constitute one of the greatest wildlife spectacles known.

If one is interested in birds rather than mammals, some rarities can be found in national parks. About 1915, the trumpeter swan was thought to be almost extinct in the United States, although it was known that there were a number still left in British Columbia. A number of pairs persisted in nesting in Yellowstone Natonal Park. They were given special protection and, now, there are over 30 pairs nesting regularly in the Yellowstone region. The famous grouse which changes its plumage from winter to summer, the ptarmigan, is abundant in most of the high mountain parks of the northwest and Alaska.

Nor should I leave out the reptiles. Throughout the southwest,

there are to be found many beautiful lizards, like the collared lizard which is not only beautiful in color but reminds one of the dinosaurs of old as we see it rear up on its hind legs and rush across the sand.

In still other parks may be found the works of ancient man. Mesa Verde National Park contains hundreds of great cliff dwellings which were the first apartment houses built on this continent. Some of them furnished a home for hundreds of Indians. As one visits these old ruins, he attempts to picture in his mind, from the evidence presented, the activities of the people who possessed the land before the white man came. Still other parks in the Southwest present the Indian as he is today.

I have outlined some of the scientific features of the American national parks. You are invited to come to see them for yourselves. When you do come, I trust you will come with a seeing eye and a hearing ear. Miss Margaret Farrand wrote this verse which describes what might well be a national park scene and then makes a pertinent comment:

> "A curve in the road and the hillside clear cut against the sky,
> "A tall tree tossed by the autumn wind and a white cloud drifting by,
> "Ten men went along that road and all but one passed by,
> "He saw the hill and the tree and the cloud with an artist's mind and eye
> "And he put it down on canvass for the other nine men to buy."

I hope that you will go with an artist's and scientist's mind and eye in order that you may be able to appreciate the marvelous scenic wonders of the American national parks.

AVIATION

T. R. LOUDON

Two years ago on my return from England, I made the statement that Canada was at least five years behind the times in aeronautic progress. Since then many who have the necessary authority have publicly demanded that action be taken to place Canada in that position which she should rightfully occupy; and at the present time I have no hesitation in saying that we are catching up very quickly and no doubt two years from now we shall be back in that position which we should never have relinquished.

We seem to have forgotten that the Canadians—Baldwin and McCurdy—in 1908 and 1909 were the first in the British Empire and among the first in the world to fly. It is my opinion that some fitting national action should be taken to keep these names in front of our young people so that they may know that, in those days, there were men willing to risk their lives to learn many of the things which are now so easily taken for granted.

And we must not forget that, at the end of the Great War, a very large percentage of the Royal Air Force was made up of Canadians which, at that time, was taken to mean that we were an air-minded people. It is my contention that this characteristic of air-mindedness has not been lost in one generation; indeed, if anything, the evidence points to the fact that among the young people air-mindedness has increased. This being the case, we have in Canada the outlook necessary to handle all phases of the aeronautic industry, if we provide the necessary training.

There are many of the older people among us who have the idea that aviation is still in the highly experimental stage and that travel by air is a dangerous procedure. May I quote you a few figures which I think will refute this idea.

	Route Mileage	Mileage Flown
1919	3,000	1,000,000
1925	34,000	31,000,000
1929	125,000	53,000,000
1933	200,000	100,000,000
1936	300,000	200,000,000

It is hardly conceivable that this immense amount of travel takes place under highly experimental conditions. And if additional figures are required, there is the case of the Imperial Airways plane "Heracles" which, from 1931 to date, has flown one million miles.

In considering the historical aspect of aviation, I divide the development into three periods: the prescientific, the early scientific, and the intensely scientific.

During the prescientific period, many men of courage and vision but lacking in any scientific knowledge tried to imitate the flight of birds. There is the case of the man who, in the twelfth century climbed to the top of a tower in Constantinople and, with large bat like wings attached to his arms and body, launched himself into space and, as the record reads, "did dash to the ground and break all his bones, whereat the crowd dispersed laughing merrily." This was the case with many attempts. Leonardo da Vinci, in the fifteenth century, seems to have been the only one, up to the early nineteenth century, who had any glimmering of scientific principles.

In 1809, the first real scientific contribution was made by Sir George Cayley in England, who pointed out that wings should have an arched or cambered cross section and not be flat as had been used previously. This was a great advance, but it was not until 1881, when Horatio Phillips patented his famous airfoil section, that any real approach to the present airfoil sections was made. Progress from then onward was fairly rapid. The Wrights following in Lilenthal's footsteps undertook gliding experiments in 1900, and, in 1903, they actually flew in a motor propelled machine.

It must be kept in mind that the gasoline engine began to come to the front during this period and provided motive power sufficiently light for aviation purposes. In 1904, the Wrights flew for five minutes and four seconds. In 1905, Wilbur Wright remained in the air thirty-eight minutes. Unfortunately, the Wrights kept in seclusion and it was not until 1908 that they emerged to demonstrate the real efficiency of their machine.

At the same time, great progress had been made in France and England. But in 1908, the Wright's competing in France showed that in manoeuvrability and reliability their machine was still the best. They insisted, however, upon using their clumsy starting rails, refusing to use wheels for a landing gear and thereby lost in favour to less efficient but more practical machines.

1909 was a year of great triumph. Bleriot flew across the English Channel. It must be remembered that these planes flew at comparatively low heights. A few hundred feet was sometimes their maximum flying altitude, and as a consequence they were subjected to all the turbulence of low levels. The maximum height for 1909 was 500 feet reached by Latham. During this same year, Moore-Brobazan won the "Daily Mail" prize of £1,000 for the first circular mile flight by a British aviator on a British built machine, his aeroplane being built by Short Bros., the famous constructors of the new Empire Flying boats of the Caledonia and Cambria class.

From this date onward, we enter the intensely scientific period. The advances have been many. Scientific research has been carried out until, at the present day, it is possible to find authoritative information on almost every phase of aviation. Great tunnels, capable of taking whole full-sized planes, have been built to investigate problems under almost practical flying conditions. The result is that we in Canada are now less than one day from the centre of the British Empire. We now live truly in the world.

You will notice in all the information I have given you verbally and by means of illustrations that the great progress in aviation has been made in the British Empire and the United States,—the peace loving countries of the world. And yet many go throughout our land preaching peace in the land of peace. It may be that those who do so and who fail to preach peace in the lands of the disturbers, do so for a purpose. Many of these people fear our air-mindedness, for it might interfere with their plans of world domination. I would warn Canadians to cherish their great gift of air-mindedness. The peace of the world may depend upon it.

BUTTERFLY GEOGRAPHY

WM. T. M. FORBES

The purpose of the study of the distribution of animals and plants on the earth is the light it throws on the past history of the earth's surface. Thus if butterflies are now found in two widely separated areas, we must develop a theory as to how it happened, and determine if they most probably migrated from one to the other over land now lost (land bridges), or over some area now climatically closed to them, proving the past existence of a different climate. Perchance they may have been exterminated in the intervening area by some more modern and aggressive type. Each group of animals and plants makes some special contribution to the picture, as its means of migration will be different and the barriers which stop it partly different, though there will be much in common. Butterfly geography is merely a special case of zoogeography.

The butterflies are a practically useful group in that they are extensively collected, rather easily stored and studied, and their classification is well established, so that we are not often deceived by mere accidental likenesses. As they are smaller than birds or mammals, they can survive as a colony in more limited areas, and as they can cross narrow water barriers, they give a special light on land masses that have long been separated just a little from their nearest neighbors, such as the West Indies and Celebes.

For practical mapping in animal and plant geography we divide the world into regions, roughly corresponding to continents, then into subregions, provinces, faunas and colonies, much as geographers divide the world into countries, states, counties and towns. The boundaries represent the great barriers to animal (and butterfly) migration, and first of all the great seas. Study of distribution shows the areas do not exactly correspond to the geographical continents, but may be marked by climatic changes and bounded by mountains or deserts. Thus the Nearctic and Neotropical areas correspond to the continents of North and South America, but are bounded, not by the isthmus of Panama, but by the point in Northern Mexico where there is no longer a marked difference between summer and winter. Between Palaearctic (Europe and northern Asia) and Ethiopian (Africa), the boundary is, not the Mediter-

ranean, but the desert of the Sahara and central Arabia; between the Palaearctic and Oriental (India, etc.) it is the Himalaya mountains.

Every one agrees that Australia has a very different fauna from India, but the fauna changes very gradually as we go down the intervening islands. We tried to draw a boundary by studying the eastern limit of butterflies characteristic of India (Swallowtails were mapped), and similarly the western boundary of those at home in Australia and New Guinea. We found that the islands, including the Philippines and the Sunda Islands even to Timor, went with India, and the Moluccas with New Guinea, but the Celebes largely lacked butterflies special to either. Later the Celebesian types were discussed, and their more distant relationships showed they were derived, on the whole, from those farther west. But, on the basis of mammals and birds, Wallace originally put the boundary further west, west of Celebes, and in the Sunda Islands, only a little east of Java.

In subdividing regions, differences of climate have proved to be more important than barriers on the whole. For the Nearctic (Canada and the U.S.), Merriam's map of the "Life Zones" shows temperature as the chief control of distribution, but humidity, as shown by Thornthwaite's map, also divides the area into three blocks, a humid eastern half, an arid west, and a second very humid west coast strip, crossing Merriam's life zones at right angles, and also controlling butterfly distribution.

For the world as a whole, Thornthwaite's map, showing moisture, and a map showing the areas of plant types (forest, grass, arid and cold) have been compared, and have shown rough correspondence.

Modern types of animals, (i.e. those dominant under present conditions on the earth, and probably of recent developmnt on it) show distributions that are wide and continuous, without any breaks, and only with gradual changes of appearance from place to place. Thus the buckeye butterfly (Junionia lavinia) ranges from southern Canada to Patagonia with only two marked changes of racial type, and these gradual ones.

In contrast, ancient types that were adapted to past conditions and have suffered partial extinction show limited and patchy distributions, often interrupted by areas where they no longer occur. Thus the Pterothysanidae, ancient relatives of the geometers, show

four patches in Asia and Africa, and the two most closely related occupy entirely separate spots in southeast Asia and Madagascar. The Hypanartia butterflies now occupy wholly separate blocks in tropical America and Africa, with a single rare species isolated in New Guinea, while in this case their early wider distribution is proved by a Miocene fossil in Colorado. The true swallowtails (Papilio) show their modern origin by their tremendous range over the surface of the earth, and the wide range even of single species. A group of closely related genera (Thais, Leptocercus, etc.) show isolated patches of distribution, mostly in Asia, but also in Australia, Mexico and southern South America. The snout butterfly (Libythea) seems to show a case of recovery. A few species show the tremendous range and continuous distribution of a modern type; but a single rare species got lost in the Marquesas, a thousand miles from any of its kin. When we consider the relationships of this form, we judge that the Marquesas have perhaps been cut off from the rest of the world since the Mesozoic, perhaps even longer than Australia. In this case Mammals give us no light at all, for none ever reached this last island of Polynesia (short of Hawaii).

A curious case is provided by those butterflies found (in related forms) in the temperate old world and tropical new world, but not in the intervening temperate America. Examples are Thyatira, the Dismorphiinae, Hypercallia, and the closely related "Sulphur" genera, Gonepteryx and Phoebis. The solution appears when we study the fossil history of the Camels, for here we find the same identical distribution. Although they originally occurred in North America, the glacial age finally exterminated them. Obviously, only cold types capable of crossing Behring Strait could filter into the Old World, where they have ever since been at home only in cold areas, while only those adjusted to the climate of Panama could get across into South America. Just how the North American forms came to be so completely annihilated, however, is not clear. But it must have been in some way due to the combination of glacial conditions and perhaps Pliocene volcanic activity. We can hardly call in man to help, as we do with the camels.

Two areas will serve as an illustration of what happens when a land is long separated by narrow breaks from the larger areas—the Greater Antilles and Celebes. In this case forms filter in, partly by accident, over the whole period of history of the areas, and we get a fauna of odds and ends. Thus the greater Antilles show

ancient types that have survived there (Papilio columbus), stragglers apparently from the old world tropics (Papilio homerus with its closest kin apparently in Australia, Cystineura teleboas with a close relative in Africa), and others connected with west Mexico (Dismorphia spio), Central America (Clothilda) or the Andes (Hymenitis). Others are wide-spread and modern. In the case of the Celebes, forms are a kind of exaggeration of their neighbours (as shown by Paplio antiphates and a Parthenos) and a few surviving forms show that the Philippines formerly had a similar fauna now nearly swamped from the west (Faunis).

Mountains may produce the same kind of isolation with slow leakage of forms over a vast period of time, as shown by West Mexico, which has ancient relicts like Baronia (the oldest kin of the swallowtails) and many others.

The oceanic islands, which were never connected or even close to land, were populated in the same way, but even more erratically. Examples are Hawaii on a grand scale, Bermuda, with practically nothing but modern visitors from North America, Kerguelen with only a couple of wingless Tineids.

The glacial periods show their effect in two chief ways. In the temperate zone, the effect is shown in the isolation of forms of cold type, far from their Arctic relatives. These went south with the edge of the ice, then failed to follow its retreat and were cut off, as with the Appalachian white, Pieris virginiensis, which finds its closest relative (P. napi hulda) in Alaska. Also the other forms of napi show the trace of successive waves of invasion from the old world, two represented by oleracaea and castoria, and perhaps even a third, which explains how the green-veined whites from western Canada are more like the old-world types. Certainly these must correlate in some way with the successive waves of glaciation, the rhythmic changes of climate, and alternate opening and closing of migration via Behring Strait.

In the Tropics, the effect is shown by the extremely limited number of really structurally distinct species of the hottest tropical types, such as Mechanitis and Melinaea, which have evidently reoccupied their present territory almost exclusively—for their present "species" differences are wholly superficial. On the contrary, the cooler types, which could migrate up and down the mountain sides, have survived in large numbers of every distinct species.

Papilio machaon (the "Swallowtail" of England) shows the effect of glacial conditions in its tremendous range in the north generally,

where related forms cover the range from England to Alaska, while in two places earlier types must have managed to survive, in Thibet (montanus), and west of Hudson Bay (hudsonianus).

There are two theories as to how new types are produced. The current one is that they develop at the limits of a species' range, where conditions are most extreme and selection is most likely to operate in a new way; and the other, the so-called "Age and Area" theory, that they arise near the centre of distribution of a species, where competition within the species is most active and orthogenetic tendencies are presumably most active. My conviction is that the first case is more usual in the butterflies, but several examples are shown where a later type has arisen within the area of an older, and left the latter in isolated patches around the edge. Thus, in the black swallowtail, the black female has replaced the male-like one except in Cuba, the area about the mouth of the St. Lawrence, and in central and northern South America, at the three limits of the species; in Heterosais, the orange form divides the yellow form into two separate colonies and, in South America, the tailless swallowtails of the Aristolochia group have divided the tailed ones into a northern and a southern subtropical block, while they monopolize the tropical centre except for two very rare species.

Finally it must be remembered that while all these phenomena have been discussed on the scale of the world or great areas of country, the same laws apply to the minuter distribution from field to field. The butterflies of two neighbouring wood-lots on a farm will show, on a small scale, the same distribution problems as those on two great forest areas of the world—only the space and time factors are smaller. And, in the same way, we must decide whether a species common to two such areas has been there since they were one, or if (and how) it was sometimes transported from one to the other.

PRODUCTS OF ELECTROCHEMISTRY

COLIN G. FINK

HISTORICAL

Electrochemistry had its beginnings in the very first years of the nineteenth century, marked by the classic discoveries of Volta. Thirty years later, Michael Faraday, at London, entered upon his epoch making experiments which laid the scientific foundation of electrochemistry for all time. Faraday's discovery of the rigid relation between the weight of metal deposited and the quantity of electricity passing through a cell has ever since been found to hold without exception. Faraday, in all of his experiments, was dependent upon an inefficient voltaic battery as the source of electric current. This serious limitation in electric current supply not only badly retarded, for almost fifty years, electrochemical research but made it impossible to develop any electrochemical process industrially. Nevertheless, it was during this period, following the brilliant discoveries of Faraday, that a number of the modern industrial electrochemical processes were originally conceived and tried out on a "beaker scale": among these were the production of ozone in 1839; metallic sodium by the electrolysis of fused alkalichlorides in 1855; the lead storage battery in 1859; electrolytic oxidation-reduction of organic compounds in 1839; electro-refining of silver in 1871. However, it was not until after the invention of the dynamo in 1877 that these and other electrochemical processes could be carried out on a commercial scale. But from then on progress was very rapid and, before the close of the nineteenth century, the electrochemical industry was firmly established.

One of the earliest and most important electrochemical centres was founded at Niagara Falls. Here was a source of abundant and constant supply of electric current, and here the inventions of Acheson, Castner, Hall, Heroult, Moissan, Willson and others could be tested and developed on a grand scale. Thus, within a period of less than a generation, electrochemistry "passed from milliamperes to kiloamperes."

A NEW ERA IN METALLURGY

The many marvels wrought by the electrochemist have had a very profound effect on our entire economic structure. Our alloy steels of today are a thousand-fold better than the old carbon steels which had been standard for hundreds of years. Without electrochemistry our automobiles and our aeroplanes would be impossible. Electrochemistry has revolutionized the entire field of metallurgy. For 5,000 years, there had been no radical change in the metallurgy of copper or of zinc or lead or tin. With the entrance of the electrochemical industry, a new metallurgy was born. Metals are deposited electrochemically in the very purest form, the foreign elements remaining amounting to less than one hundredth of one per cent. Electrolytic copper of uniform purity and ductility is the basis of our entire electrical industry. The exact duplication of intricate electrical windings and coils would be impossible without copper wire of the same electrical conductivity year in and year out.

The metal which is most characteristic of the new metallurgy created by electrochemistry is aluminum. Powerful electric currents pass through a fluid bath of salts of aluminum maintained at 1000° C. Silver white liquid aluminum metal is deposited at the cathode and then cast into ingots that are fabricated into a thousand different articles, such as structural parts for automobiles, railways, aeroplanes and ships, kitchen pots, aluminum foil, aluminum paint, high tension transmission cables, spandrels and other building parts., etc., etc. The world today produces annually 400,000 tons of aluminum metal as compared with 80,000 tons of nickel and 20,000 tons of tin.

By a process very similar to that for aluminum, we produce magnesium metal even lighter than aluminum and one of the best metals for piston heads, and for many other machine parts. Another metal of this group is calcium, a most efficient reducing agent and scavenger in the foundry; another is beryllium which, added to copper, produces an alloy that is as hard and as elastic as steel; another is metallic sodium, 150,000 tons of it a year being used in the manufacture of indigo dyes, anti-knock compounds, etc.; and another metal of this group is caesium, the heart of the electric eye without which our modern motion picture industry would be non-existent.

CALCIUM CARBIDE

An electrochemical product made in the electric furnace that has had a most remarkable, if not phenomenal, development is calcium carbide. Forty years ago its chief outlet was for acetylene for lighting. Then a few years later came the discovery of the oxy-acetylene torch for welding and cutting. Then came the discovery that, if hot calcium carbide was brought in contact with atmospheric nitrogen the latter would be "fixed,"—the first commercial nitrogen fixation process resulted. The product, calcium cyanamide, finds wide application as a fertilizer. Furthermore, it serves as raw material for the manufacture of cyanides used in metallurgy and of hydrocyanic acid gas the most effective insecticide known. Again a few years later calcium carbide entered upon the fourth stage in its development; it became the raw material for acetone and alcohols. Water reacts with carbide to form acetylene; this is hydrogenated to form ethylene, thence to alcohol, acetone acetic acid besides two score intermediate products, thus providing solvents, plastics and fuels for widely different uses. A new organic chemical industry has sprung into being. "Ethyl alcohol from limestone and coal," will, to the layman, always seem miraculous.

CHLORINE

Before the days of electrochemistry, chlorine gas, which is the underlying basis of our bleaching industry, not to mention its use in warfare, was made by a very lengthy and wasteful chemical process. Today, by merely passing an electric current through water in which ordinary table salt is dissolved, tons of this yellowish-green gas, chlorine, are evolved and so easily and cheaply that chlorine has entered into fields of application not even considered heretofore. Tank cars holding 35 tons of liquid chlorine are today shipped by rail for many miles. Sea water contains, besides ordinary table salt, a large number of other constituents, most of which are present in very small amounts. Among these is bromine, an important reagent for the manufacture of tetraethyl lead for anti-knock gasoline. By passing chlorine gas into sea water, the bromine is liberated. A large factory for the preparation of bromine in this way is located on the Atlantic coast at Cape Fear, North Carolina.

COMBATTING THE CORROSION OF IRON

Iron is undoubtedly the most important and fundamental metal from our modern engineering and economic point of view. Our railways, our skyscrapers and bridges, our machines used in fabricating millions of articles—lathes, rolls, presses, cutters, planers, crushers, grinders, and others, are all made of iron and steel. Fortunately, nature has supplied us with an inexhaustible supply of iron. The production of this metal throughout the world today is at the rate of 100,000,000 tons a year—as compared with 2,000,000 tons a year of copper, the next in magnitude. But, in spite of the many valuable mechanical and physical properties that iron possesses, it has one very serious defect. It rapidly decays when exposed to the atmosphere or the sea. The problem of combatting the corrosion of iron has occupied the front rank in research laboratories all over the world and the best means today of solving this problem is through elctrochemistry. Two more or less distinct, though fundamentally related, methods have been applied. The one method consists of melting the iron in the electric furnace and adding to it small proportions of other metals, notably chromium and nickel. Thus "rustless" iron is made by adding 13% chromium; and similarly one of the popular stainless steels is made containing 18% chromium and 8% nickel. There are several other corrosion resistant irons and steels and their number is steadily increasing.

The second electrochemical method commercially applied to combat the corrosion of iron and steel is that of electroplating. Here chromium plate is one of the very best due to its high wear resistance. Another is zinc. The steel tire rims of our cars are electrogalvanized, and many miles of steel wire are daily electrogalvanized A new comer on the market is electro-tin plate free from pin holes, for the canning industry. When properly made, nickel plated steel will stand atmospheric corrosion indefinitely. For roofing, we have the new "electro-plumbed" sheet iron. For indoor steel fittings such as escutcheons, doorknobs, wall plates, etc., a thin coating of brass is electrochemically applied. And to protect steel against the attack of the strongest acid, hydrochloric, a thin layer of rubber is plated over the steel.

The electro-tin plate referred to above, is a recent product of our own laboratory. The tinning of steel by the older method consists in drawing the steel sheet through a bath of liquid tin. The surfac obtained is bright and shiny but, upon examination under the

microscope, we find numerous little bare spots, or so called pinholes. Accordingly, the steel is not protected at these points and corrosion sets in, which, sometimes, is rather disastrous. The problem we set out to solve was to eliminate the pin holes and to apply the tin coating electrochemically. The new product is as bright as a mirror and pin hole free. Comparative corrosion tests using plates made by the old process and plates made by our new process were most conclusive. The old process plates were red with rust after a fe weeks' exposure, whereas the new electro-tin plates were still bright and shiny.

Another recent product of our own laboratory that belongs to this class of "steels with corrosion-resisting coatings" is the new "alplate" an aluminum coated steel. Here we were confronted with the problem of getting the aluminum to adhere firmly to the steel base. After years of experimentation, we found that a very tight bond between steel and aluminum would result if the surface of the steel were specially treated before coating. The new product is not merely resistant to atmospheric corrosion at ordinary temperatures but also at elevated temperatures. It is fireproof besides being corrosion proof. Test lots of alplate heated at white heat (1,000° Centigrade) for over one thousand hours were still intact at the conclusion of the test. If desired this aluminum coated steel may be dyed, electrochemically, and, curiously enough, its corrosion resistance is thereby enhanced, just as in the case of electrochemically dyed tin plate or chromium plate.

THE ELECTROCHEMISTRY OF GASES

Very fruitful has been the electrochemistry of gases. From a commercial point of view the electrical precipitation of dust and fumes as developed by F. G. Cottrell is an outstanding example. The dust or fume particles are electrically charged and caused to migrate and collect on the surface of vertically placed metal plates or on the inner walls of metal pipes. Not only has the Cottrell process removed from our atmosphere dust and acid harmful to vegetation and to our lungs, but it has, in the case of many smelter fumes, recovered valuable silver and other metals that would have otherwise been lost forever. The process is so simple that some factories, instead of avoiding smoke, find it to their advantage first to convert the product into smoke and then to pass an electric discharge through the smoke and cause it to precipitate. Thus, for example, high grade phosphoric acid is made. By volatilizing one

of the constituents in the raw material we can thus bring about a very efficient separation.

Another example of the application of electrochemistry to gases is the development of neon and helium sign lighting and the new sodium vapor lamps installed on our highways. Few of us realize how very many difficulties had to be overcome before "electric-gas lighting" became a commercial success. Researches in this field have extended over a period of more than forty years. Today when you close the switch of one of the new sodium lamps a small barium oxide coated filament starts to glow and emit electrons which render the neon gas electrically conductive, the neon gas being in the space in the lamp bulb above the solid sodium metal. An arc discharge passes through the neon gas and the lamp bulb becomes heated so that the sodium vapor pressure increases, reaching a concentration at which the electric discharge now passes through the vapor, and the whole bulb is filled with a beautiful golden glow.

CONCLUSION

The products and processes we have briefly described are all the result of electrochemical research. It is a most fascinating field. Personally, we have spent thirty-five years in this field and have never for a moment regretted it. Applying the electric current to chemical investigations has brought about many unexpected results. Simple or complex oxidations or reductions without the usual contaminating constituents; reactions at temperatures over a thousand degrees centigrade above those attainable by coke or gas; heating the reaction mixture from within instead of from without; heating in the presence of any desired gas, or none at all; the refining of metals to the very highest state of purity and the detection and isolation of rare and valuable byproducts; electric currents powerful enough to break through or melt the most refractory of materials; or electric currents so minute and mild, as those we find accompanying reactions in living organisms,—these are some of the results obtained.

As to the future, dozens of problems still await solution. We need new products and processes to convert our super-heavy railway equipment into such as will excel that of the modern aeroplanes. We need an electrochemical "machine" that will convert the vast energy of the sun that reaches the earth, most of which is wasted today, directly into electricity, instead of first converting a mere fraction of sun energy into trees and trees into coal and

coal into heat and heat into steam and steam into mechanical power and this power into electricity. We want to apply electricity to different substances and to change these substances easily and rapidly into foods as valuable as milk and as cheap and abundant as spring-water. We want to produce by electrochemical means materials harder than diamonds, metals lighter than aluminum and stronger than steel, electric lamps ten times as efficient as the best tungsten lamp today, to produce dyes that never fade and silver that won't tarnish. These, and other problems such as these, may seem fantastic today, but tomorrow may see their solution. Investigators now have means and methods at their command not even dreamed of a century ago. We have a great deal of confidence in the young research men of today, who will, we believe, solve these and many other problems.

DIVING IN CORAL GARDENS

ROY W. MINER

Dr. Miner's lecture dealt with an expedition to the South Seas carried out in 1936 to obtain material for a group, dealing with the Pearl fishers, for his museum's Hall of Ocean Life.

Moving pictures and beautiful coloured slides were skilfully combined to illustrate to his audience the beautiful island setting, the magnificent coral gardens, the exotic tropical fishes, and the pearl shells in their natural setting, as well as the methods by which the natives collect them. The unique under-sea pictures and the ingenious methods by which they were obtained were likewise illustrated, as was also the manner in which the seven tons of coral which the expedition brought back was treated and shipped. Finally, the shore life of the island-dwelling pearl fishers was described and illustrated, as well as high lights on the way home.

THE SCATTERING OF LIGHT

W. H. MARTIN

The lecture deals for the most part with the molecular scattering of light. It is best, however, to begin by considering the light scattered by particles which, though small, are many times larger than the largest molecule.

Tyndall showed how to observe best a cloud of very small particles. One need only pass an intense beam of light through the cloud, and observe it at right angles against a black background. The trace of silver chloride precipitated by addition of 50 cc. of Toronto tap water to 1000 cc. of distilled water containing a little silver nitrate becomes clearly visible in the Tyndall beam. The weight of silver chloride precipitated in this experiment is so little as to defy detection by weighing, but in the Tyndall beam it can be easily observed and can be measured if need be.

The light from the Tyndall cone has certain characteristics which are of interest:

(1). Light is emitted from the particles in all directions. This is in contrast to light thrown back from the surface of a mirror which is reflected only in one direction.

(2). The scattered light is blue, relative to the exciting light. In the mass, the silver chloride is white; it is blue only when in such a finely-divided state that each particle has a diameter less than that of the wave-length of light. Smoke from the tip of a cigarette is blue for the same reason, but smoke which has been in the mouth is white, since the particles have grown to a much larger size by absorbing water from the moisture-laden air in the mouth.

(3). The scattered light is plane polarized. This can be demonstrated by rotating a polarizing film in front of the flask containing the suspension. The beam disappears at one position of the film, and is brightest when the film is rotated 90° from this position.

THE MOLECULAR SCATTERING OF LIGHT

If a liquid (or gas) which contains no suspended particles be examined by means of a Tyndall beam, with some precautions to shield the observer from stray light and to provide a black background, it is found that the pure liquid (carbon tetrachloride) scatters light like a fine suspension, although the scattering is less intense. The light from the liquid passes out in all directions, it is blue, and it is polarized exactly as in the case of the fine suspension.

Can anyone doubt the evidence that this apparently homogeneous liquid consists of a cloud of small particles? The particles, of course, are John Dalton's molecules and they are distributed through a medium called space or "the ether." To use a happy phrase coined by one of my colleagues, the liquid is "dusty with molecules."

Proceeding on the assumption that the light scattered by a pure dust-free liquid betrays a fine structure in the liquid, we may learn much of the nature of this structure by a study of the scattered light. It is, in the first place, clear that the intensity of the scattered light depends upon the number of molecules, and that we may, therefore, count the molecules by measuring the intensity of this light. These measurements have been made by a number of workers, and most carefully by Jean Cabannaes. He finds that 1 cc. of oxygen, or of any other gas, at atmospheric pressure and at the temperature of melting ice, contains 2.7×10^{19} molecules, a value in good agreement with that obtained by other methods.

It is also possible to gain some idea of the shapes of molecules by a study of the state of polarization of the light scattered by various substances, for the theory shows that spherical molecules emit completely polarized light, while needle-shaped molecules, the extreme of asymmetry, emit light which is but slightly polarized. A few substances, judged by this criterion, appear to have spherical molecules and a few needle-shaped molecules, but most lie between these extremes. There is, to be sure, a certain vagueness in this discussion of the shapes of the molecules. The term "shapes" indeed requires more precise definition for the shape of a molecule cannot be defined as easily as that of an egg, since the same measuring stick is not applicable to the two cases. We are, therefore, forced to acquire such ideas as we can from measurements such as these on light-scattering and to take comfort in the saying that "half a loaf is better than no bread." The pertinent

proverb " a little wisdom is a dangerous thing" is not stressed at the moment.

THE BLUE SKY AND THE BLUE SEA

The study of the molecular scattering of light is of very practical assistance in the interpretation of many natural phenomena. For example, the blue light of the sky undoubtedly has its origin in the sunlight scattered by the upper atmosphere, for it is blue and it is polarized (maximum polarization when the line of vision makes an angle of 90° with that of the sun's rays) exactly as in the laboratory experiments. The question remains as to whether atmospheric dust or the molecules of air are chiefly responsible for the blue sky. This question is easily answered now that the intensity of molecular scattering has been measured in the laboratory. Calculation shows that, on a clear day at a good distance from sources of atmospheric pollution, about half the sky light has its origin in molecular scattering, and that above Mount Wilson much more light is scattered by gas molecules than by dust.

The problem of the origin of the blue colour of the sea is more difficult. The sea, like the air, is filled with motes, consisting largely of silt and microscopic creatures. Both silt and plankton are more abundant near shore and in mid-ocean the water is often relatively free of suspended matter. Even in mid-ocean, however, sky reflection must be eliminated, and this may conveniently be done by the use of Polaroid glasses, in which the polarizing film is so oriented as to absorb reflected sky light, since light is completely polarized by reflection at a certain angle. Light from the sea, when observed with these precautions, is a beautiful indigo blue, a deeper blue than sky light. The reason for the deeper blue of the sea lies in the selective absorption of yellow and red light by water, with the result that the scattered light, on its return to the surface, loses intensity in these colours so that the emergent light is an indigo blue.

LIGHT SCATTERING AND INFRARED PHOTOGRAPHY

The principles of light scattering have a very direct application to the subject of visibility in fogs or under hazy atmospheric conditions. The light scattered by haze overwhelms the light from distant objects and conceals them just as a thin curtain conceals even brighter objects beyond it. Infrared light, having a wave

length longer than visible light is scattered very little, so that a camera which transmits only infrared light can penetrate fog in a remarkable way. (Slides shown to illustrate fog penetration by infrared photography).

RAMAN SPECTRA

Professor Raman, in the course of his studies on the scattering of light in liquids, made (in 1928) a discovery of first importance even to the most practical minded chemist. He found that, when a liquid was illuminated by a beam of monochromatic light, the spectrum of the scattered light showed, in addition to the exciting line, certain other lines of feeble intensity, and that the frequencies of these Raman lines were characteristic of the liquid. The Raman spectra of all the common substances have been charted and have already been used in identifying the constituents of complex mixtures. For, in a solution of several liquids, each component leaves its signature on the photographic plate. A new type of molecular spectrum is, therefore, available which is more easily obtained and, therefore, of greater practical use to the chemist than most other types of molecular spectra.

But the chief interest of Raman spectra is theoretical. A comparison of the Raman spectra of a number of simple substances suggests at once the type of theory required for their explanation. Argon, a monatomic gas, has no Raman lines. Oxygen, hydrogen and the other diatomic gases have each one (vibrational) Raman line, and for more complex molecules the number of lines increases rapidly with the number of atoms in the molecule. A first guess, therefore, would be that each Raman line betrays one mode of vibration of the atoms within the molecule. Indeed, if we build mechanical models of molecules of springs and small weights, they vibrate in just this way.

Raman spectra, therefore, show how molecules vibrate, and, from the knowledge of the modes of motion of their molecules, some of the physical and chemical properties of substances can be predicted. For example, the yield of wood alcohol, which one might hope to obtain by passing a mixture of hydrogen and carbon monoxide over a suitable catalyst, can be calculated, if the spectroscopic data for these three substances is available. Those who make these calculations are almost wizards. From the colours of gases they predict how they may react and what the yield may be,—surely a

very important and practical matter in the case cited, for in the United States of America 120,000,000 pounds of wood alcohol were made by this method in 1935.

Scientists fortunately can justify their pursuits by such arguments, but it is for quite a different reason that they work at these things. The reason, of course, is that they find the experiments interesting.

THE SCIENTIFIC MAN IN PUBLIC AFFAIRS

ROBERT C. WALLACE

I feel highly honoured to be asked to speak to this distinguished organization, even although it is but a case of adding to the many addresses you have already heard. I hesitate very much, the more so as I get older, to add to the chorus of public speaking. After all, there is so little to be said and it is said so frequently and in so many different words.

I am reminded of an incident which I must not repeat after this evening, but which I hope some of you have not heard. This occurred in one of our Western Legislatures at the time of the debate on the King's Speech which, as you know, is an occasion for all and sundry legislators to speak on everything under the sun. Even with that great scope, they repeat themselves very often before they are through. There happened into the chamber one evening two old ladies who had been in the habit of going to picture shows together in the evening. They sat and listened for two and a half hours or more to the speeches on the address from the Throne, until, finally, one of the old ladies leaned over to her neighbour and said, "My dear, I think this is where we came in." I am quite sure before I am through you will say, "This is where I came in."

I am led to understand that you have been in the habit, in this particular organization, of hearing detailed discussions on certain aspects of science. Now, there was a time when I might have made a contribution in that direction; but the business of administration, with all the petty little details that take up a man's full day and his thoughts during the evening and sometimes the night leaves, unfortunately, very little time for carrying on in one's chosen field. I am not going to attempt to do something I should not do,—a detailed discussion on some aspect of my particular science. I thought, therefore, that the only thing—the best thing, at least—I could do, would be to take a more general phase of the question which has occupied my thoughts from time to time and try to analyze it with you. In other words, simply to think aloud this evening, quite informally, and without, I am afraid, reaching any very positive conclusions at the end of it.

It is the question of the scientific man in public affairs, or science and its devotees in relation to public questions. Those of you who are scientific in any particular specialized field of science and who, therefore, read "Nature," the premier publication on science in the world today, will realize that this subject has been thought about and discussed in "Nature's" editorials from time to time in past years, always with a question mark as to whether the scientific man is really taking his rightful place in the conduct of affairs today. It is that question that I wish to consider with you this evening. I think it is a very important question and I doubt whether any of us is completely satisfied with the situation as it exists today.

Not so long ago, Julian Huxley, whom many of us had the pleasure of meeting and listening to when he visited Canada a few years ago, wrote a little book which was the gist of a series of radio talks he had given over B.B.C. on "The Place of Science Today in the Industrial World." It was an amazingly provocative book, even to those of us more or less in the field of science. It opened many new lines of thinking and a great deal of new knowledge to us. What Julian Huxley had done was this: In order to obtain the knowledge he wanted on the matter, before speaking over B.B.C., he had visited a great number of different kinds of industry in Great Britain and had attempted to analyze exactly what science was doing today for those industries. His book consisted of a remarkable presentation of science in its present effect on the industrial world of Great Britain and, incidentally, of the appreciation of industrialists in Great Britain of the value of science, and of the need of using men trained in science in their particular industries to carry on pure research, in order that, out of it, something may come of value to that particular industry.

In that side, at least, it showed us something that we have not yet fully appreciated in Canada, where, as yet, industrialists have not to any great degree directly used the scientists, but have had to rely on the public bodies, such as the National Research Council, for scientific applications that might be of value to them in their own particular industry. In that field, the United States is far ahead of us and is showing us the way.

It is necessary for us only to think for a minute of what science means in our daily life to realize how utterly we are today dependent on the fruits of science. The last hundred and fifty years has revolutionized our whole mode of living, because of the develop-

ment of science during that period. The clothes we wear are made of materials which science has obtained for us. We have bred the animals for the particular purpose of getting the kind of raw material which we now need. The food we eat, almost all of it, with extremely few exceptions, has been got for us by the processes of science. The animals or the plants have been bred particularly and specifically for our use. They were not there before. The transportation that we use in going down to business, to our office or to work, is the result of science and its development. The communications, that we use today in speaking to people whom we need to speak to across the country, are the result of science. The amusements, that cater to our enjoyment in the evening, are all brought to us through science. The facilities, which the city provides for our living as we do in large groups, are all the result of scientific investigation, and we are completely and utterly dependent on them today. Were they to stop, life would also stop. In short, we are, as far as the outwards of our civilization are concerned, almost completely dependent on science. We do not think about it. We have accepted it, but the fact is there.

So there is no question whatever as to the amosphere in which we live. There is no question whatever, if science were to stop and if the results of the last fifty years of scientific investigation were to be obliterated, if we were to live at all we would go back to a subsistence living, a peasant life. We could do nothing else. We would do so immediately and at once. As a matter of fact, most of us would die. That is where we are now as a result of the last 150 years.

I am not saying anything about our level of thinking, our inward life. I may have something to say of that afterward. I am speaking purely of the outward garments of civilization. About them there is absolutely no question. We are the product, today, of generations of science, and there is nothing that plays so important a part in our lives as does science and the continued forward movement of scientific investigation.

Now, I wanted that to be clear at the beginning, because I think we must have the background of what I am going to say somewhat clear in our minds first.

Let us get away from the purely material background and think about the scientist. How is it that the scientist is, in this particular field, so powerful? How is it that he has had so great

an effect on the civilization of the world? Well, I think, primarily because of his attitude to his own work. Never until the scientist really became powerful through the experimental method was the analysis and testing of facts so important as it has become through his particular method of working. The scientist has elevated facts, their importance, the value of methods of checking their validity, almost above everything else. Not only has that had its effect on science,—it is indeed the very foundation of all science, —but it has had, by implication, its effect on other fields.

I may have the opportunity to say something about the difference between science and the social studies, the studies which deal with man in his inward life, later, but I want to say this, that I think the scientist has given to workers in other fields this particular respect for facts. I feel fairly sure that the historian, who has to work in fields which are beclouded by natural prejudices and ideals and patriotism, and where the facts have been distorted for that reason, has been affectd by the scientist and is, like the scientist, attempting to eliminate from the field of history all those misrepresentations which were there in order to elevate the patriotism of a particular people. The historian is becoming objective, like the scientist, in his own field of work. That, I think, is a contribution from the scientific method.

We respect and value facts. We attempt to get them, either by reading or by going to the people who know them. Before we do anything else, that is the first step and that, I think, is the first product of science to the world, and one of the greatest contributions it has made. Take the field of religion, which is mainly an emotional and not an intellectual field. Even there we respect the facts, we want to try to get at real facts back of any particular dogma of religion we may happen to hold or not to hold. The enquiring mind, free and open and impartial—that is, I think, the product of science and the greatest contribution that science has made.

Now, that is the first point where the scientist makes a profound impression on the world. The second point in the world of affairs is that he has a good grip, generally speaking, of conditions, physical and otherwise, of the country in which he lives. Naturally, he knows the country. He deals with that phase of things, and he approaches his own country and what he can do for it on the basis of a pretty considerable and sound knowledge of the

country itself. No matter what particular phase of life or inanimate nature it may be, he knows the background. For that reason, he is the man to whom people come in order to get the perspective in connection with any matter that may be the issue of the moment. He has a practical grip of the situation.

But science has done a much more important thing than that. It seems to me that this is where science parts company with the other fields of knowledge. The scientist works first on facts, and attempts to establish them. When he assembles enough of them, he generalizes. He establishes what may be called a law, that law simply being the concrete statement representing the truth, the common statement for them all. The law is, after all, only an average of a very large number of cases. It is not necessarily true for each individual case; but it must be true for by far the largest number of them. There can be only very few exceptions if it is to be a sound law of nature on which to work. It is only more recently that we have realized that the laws of nature were averages. We once thought that they were a completely true picture of nature. We now are beginning to realize that they are a good, average statement and by and large can be taken to be representative foundations on which we may safely build.

Take a simple example; the air inside a closed vessel exercises a certain pressure on the walls of the vessel, and, if air is heated to a certain higher temperature, the pressure is higher. A law can be established in reference to that relationship of pressure and temperature. The particles of air bombard the walls of the vessel more frequently because the particles are moving faster and consequently, because of that bombardment, the pressure is higher. That law does not tell us what each individual particle may do. It is not possible to follow down to the measure of each of millions of particles but only to take the average.

Now, out of those laws, it has been possible for the scientist to do something that only the scientist had yet been able to do in his field. Given certain conditions, not only certain things do happen, but certain things will always happen in the future, even in the long distant future, without fail. In other words, the scientist has been able to project himself into the future and tell exactly how things will take place, probably millions of years from now in a particular field. The simplest illustration is, of course, in the field of astronomy, when it is known to a second when an eclipse will take place, thousands of years hence. That is the

potent weapon which science has placed in the hands of man. It has become tremendously powerful. We can count on certain things happening in the future at certain times, certainly in the field of the physical or inanimate, not quite so clearly in the field of the animate. No other field of knowledge has been able to obtain that tool. The historian has learned much more about the movements that have taken place in the past and why they have taken place among the peoples of the world, but no historian would be foolish enough or brave enough to say what will take place five years from now in the world. He cannot.

I think we do not fully realize that that power to "exterpolate," as the scientists would call it, to project into the future, has become tremendously powerful and has made the scientist so important in the world today. One can build on certain facts with assurance for the future. Think what it would be if we could build on certain social facts with assurance for the future, to be quite sure, for instance, that certain new social methods of government or of economics would produce definitely certain results! How happy we would be! How definitely, for instance, we might all be Socialists, if we could be absolutely sure that certain conditions would produce certain results, but we do not know, we cannot tell. We have no means whatever, as yet, of knowing. That is where the difficulty is. It is that distinction between pure science and the social studies that is the gap which may always be unbridgeable between the one field and the other. I do not say it necessarily will be unbridgeable. It may be that we do not yet know enough about man and his mind and his prejudices and his passions and how he is affected by this thing and that. When we do know enough by studying him sufficiently fully,—I mean by "we," those who follow the social studies, the social sciences, as they are sometimes called, history, sociology, psychology, economics and the rest,—it may be possible, as with the pure sciences, to prognosticate, to say this will definitely be so, if we do certain things. If that time were to come, we would all see a very great progress made in the world. Until it comes any progress will be very tentative and, in all probability, we shall take very short steps, because we do not know what the result of each step will be.

Now, that is the point I think it is important to make clear. It is not that I am elevating one field against the other. I would be the last to do so. I am attempting to illustrate the differences between science and what are sometimes called, I think wrongly,

the social sciences. I do not think that they are sciences. I think that they are studies and I do not think it is possible to use the methods of science in the social field, completely, at least. It is true, there are certain things that can be done. Take the law of averages, the law of nature. The statistician uses it in the field of insurance. If he finds 100,000 quite healthy young men of 20, he will say that their life expectancy is, let us say 37 years, that they can be expected to live until they are 57. The insurance companies build on that general law of averages for the duration of life of the human race and, as we are bound to admit, during the very difficult time of depression, they have built rather well, because they have withstood the depression. But that does not say what any one young man is going to have as his expectancy of life. He may only have ten years, he may only have five. It tells nothing whatever about him. It tells only about the hundred thousand or million, on an average. You see that there is a considerable similarity in what is a social study and in what is the physical realm in this law, as we call it, of averages.

But, beyond that, it is not easy to correlate science and its methods with the understanding of human nature, or the methods that the psychologist and the philosopher and the historian and the psychiatrist and the economist have to use in attempting to understand this human nature of ours. The fact is, I should imagine, that the conditions are so complicated, there are so many factors, many of which are not fully known in man, that it will take a long time to have them so tabulated that they can be made responsible to any particular law. This, at least, all are assured of; we are a long distance from that yet, whatever may be the result of what unquestionably will be the more intensive work on the human sciences during the next fifty years.

I now propound the question which was the one really at the back of my mind when I chose this subject: If that be so, why is it that the scientist does not take a larger part in public affairs than he does? Why is it that the scientist is not an administrator, is not in the field of politics, is not in the field of government, is not in those critical positions where he can exercise the final choice and decision? That is the question that "Nature" has been asking in its editorial for so many years back. "Nature" says that the scientist does not get his chance, that he is not chosen as the man to do that kind of responsible work. The fact remains that scientists are, generally speaking, not in those fields. They are occupied

by men trained in other directions altogether. The question that I wanted to discuss with you this evening is, I think, a fundamental and an important question.

First of all, I would offer one or two suggestions. In the main the scientist is a man who does not want to be in those fields. He is concerned with the carrying on of his own work in the laboratory. It is a work that demands all his time and thought. He cannot do it and do other things as well. He cannot do it and think of the innumerable details that enter into administration. It needs unbroken thinking and the best thinking that he can give.

I have been reading recently, as I am sure some of you have been reading, a most stimulating book, the autobiography of Sir Joseph Thomson, called, "Collections and Recollections," the man who represented in himself the advance of physics during the last fifty years in Great Britain, the man who is primarily responsible through himself and the men he gathered around him in the Cavendish Laboratory, for the great advances that have taken place in the subject of physics. I have been struck with the fact that Thomson, although much interested in a number of things and with a very active type of mind, gave his energies and time to the work, which was to attempt to understand the nature of electricity passing through gases and, through his studies, something of the nature of the atom itself and its internal arrangement. He thought that that was the most important thing he could do and he was one of the best minds that Britain had. He thought he would do more in doing that than in going into a field that looked bigger, perhaps, to some people, more in the newspapers, more apparently influential. He did it without a single thought about any practical things that might come out of it in his own work. Thomson's whole work was the work of a pure scientist with no thought of the practical result that might accrue therefrom. There have been many very important results even in his own time, but that was not why he worked. His concern was to peer into nature and, if possibly, to unlock her mysteries and certainly he, at least, thought there was nothing more important that he could do than that.

So I would take it, one of the fundamental reasons why the scientist is a scientist in his laboratory, primarily, is that that is where he wants to be. That is where he thinks he can do his part for the world best. But I think there are other reasons. The scientist, although he is a man of great imagination—no one can

carry on the work of research without imagination, without entertaining many hypotheses which may explain certain phenomena—holds his imagination under great control by the facts before him. Notwithstanding this, his field is in the world of facts and their interpretation. The world of public affairs, speaking now from the standpoint of the public affairs, say, of the statesman, who occupies the first place in the newspapers and, indeed, in the minds of people generally, that world is a different world. It is not a world where you can get the facts and on the basis of the facts establish policy without other questions arising as well.

One of the members of the present government in Ottawa who is a business man and a business man of very considerable reputation, was heard to say not so very long ago that, when he went into the government, he thought he could handle his part of the government in a business-like way, as he would his own business. He was not long in government until he found that that was not possible, that there are many other considerations than the pure business facts that have to be taken into account in governmental policies. It was a surprise to him but he agreed that it had to be so.

The field of affairs is the field of compromise, not necessarily of getting the thing through that should be done. I had a talk today with a gentleman who was a Premier of one of the provinces some years ago. He said that, to him, the most unsatisfactory part of all his work was just this: that he saw a policy that he thought was a good policy for the province; he would call in a man, perhaps one of the Cabinet whom he trusted, and talk the matter over with him. That man suggested some changes. He would then call in the Cabinet and discuss it with them. They would suggest the leaving out of this or that as not being politically wise. He would then get the caucus and they would cut out a good deal more as being politically unwise from their angle. He would then present it to the House as a government measure and when the House was through with it he didn't recognize his particular policy at all. The worst of it all was that he had then to defend this thing to the country a large—something that to him was not by any means sound policy.

Now, I think that this gentleman was a pretty wise man. He was stating exactly the situation in public affairs. I am not blaming any conditions for that. I am simply stating what appears to be a fact, that, in a world of democracy, one has to get just as far as it is possible to go and that distance may be so small that

it is hardly worth anything at all. The real policies which would be sound are quite impossible because of the condition, more usually, of the mentality of the people who in the long run have the final say in the matter. It is a world of compromise. It is a world, not of the facts so much as the interpretation of, or reaction to, them by the people at large.

Now, that is a field in which the scientist is not at home, indeed, where he does not want to be at home, because it is so alien to his own methods of approach to his own work. Consequently, he finds himself in such cases very much disinclined to carry on, and very much happier back in his laboratory where he is dealing with the analysis of facts. I think that has a great deal to do with that matter of the criticism scientists themselves often make, that they are not placed in responsible positions in policy making.

But there is a third thing that is more fundamental. So far I have been speaking for the scientist. I think probably I should now begin to speak for the other side. The field in which the scientist works is a limited field. It does not embrace the whole of the truth. More and more do the scientists realize that it is a limited field and that they do not now speak for universal truth as coming out of science. It is a field that has applications only to the inanimate and to possibly the lesser developed phases of the animate. When one gets to the stage of man, with his thought processes and his emotional life, science says that as far as it yet has gone, at least, it has very little to say. It is perfectly true that we have been burdened, I think, with the scientific method in sociology and in education where statistics, and statistics mountain high, have been piled up in order to attempt to understand mathematically how people carry on in groups together, how they behave as human beings. It is perfectly true that we, who are in education, have been reading, ad nauseam, about the aptitudes for various professions and trades and the tools in education that are to be used to develop those aptitudes, on a statistical basis, analyzed as a scientist would analyze it. But, if the rest of you have the same feeling of approach as I have, you begin to ask yourselves whether or not in all this analysis down to the ultimate, the real thing is not escaping from the pan of the balance altogether. I feel that we shall never do more than just the very limited outworks in building up education by the scientific method. I think it is something apart from that and, may I say, deeper than that.

What we are dealing with in human beings is a complex of thought processes and emotional reactions, imperfectly understood, even by ourselves of ourselves and certainly very poorly under stood by us as far as other people's reactions are concerned. That is a field in which a scientist is totally at sea. He knows nothing about it. It is the field of human beings. That is the field the statesman, the politician or administrator, or what you will, has to deal with. For that reason, I think, the scientist finds himself unable to approach the problems in the way that the man who has contacts in other fields does. If you check up among the educated men who are in public life—politics, for instance—today, anywhere, you will find that it is the men trained in the classics or the men trained in philosophy, or the men trained in history, or sociology, that are in those fields. It is easy for us to say that is the product of the public schools of England who train into the Civil Service, into the diplomatic world, or directly into politics. I do not think that is an adequate or satisfactory answer. I have the feeling that we, as scientists, are inadequate in certain directions and admit quite freely that we are. An able scientist is no better at dealing with some public question which is emotional in reaction where people are becoming heated up about it, than anybody else is. He does not take over his particular training into that area and, indeed, he does not know how to deal with it.

I want to say something here and quite frankly for those sciences or studies which are not scientific, the studies which deal with man, his background, his ideals, his imagination, his emotions, his mind. I want to say, quite frankly, that I think that these will always be the studies that men will develop primarily who are concerned about administrative work, which means, after all, dealing with people. Everyone of them is different from everyone else. One realises that when a stream of people comes in to one's office during the day, every one is different from every other and has to be dealt with somewhat differently, just because his reactions are different. When a man has not been trained in those fields of analysis and appreciation, he finds himself at a disadvantage, I should think, against the man who has been so trained.

I think that it is time for a plea for the humanities. The humanities are, after all, the subjects that deal with man. That is the meaning of them. They are in danger of slipping away today. We are in a scientific world. I showed that, I think, clearly at the beginning. Because we are in a scientific world,

scientific training has become dominant in itself, pure and in its applied sense, and, in any university today, the professional schools are apt to be the strong schools. At least, I know no university where it is not so, among those I know on this Continent, and the student who takes Arts says, "After all, what is the use of this? It gets me nowhere. It is only a step before I go into my professional life, the professional school," and the students in Arts are, I think, not playing the part on the campuses today that they should. Fundamentally, these fields, if they mean anything at all, should be the fields of the study of man, his background, his culture, his ideals, his standards of morals and the background of those standards; his deepest thinking on the ultimate nature of things in philosophy; the study of his own mind, a study which has not yet progressed very far, in psychology; his understanding of what language does for thought and how far language may be necessary, even for elementary thought. How valuable, therefore, is a precision and a certain elegance in the use of language, a precision which comes, I think, probably best through the study of other languages; and, finally, his appreciation of the deeper things that are eternal, in what we call religion.

All that is the realm of the arts and it is a realm that is profoundly important, as it has been in the past, because through that field we attempt to understand ourselves and the people around us. We cannot deal with policies until we understand the means that have to be used to carry them through, namely the people themselves, our neighbours and ourselves.

Can we do it by persuading students to take Arts before going into the professional schools? I am not so sure that we can today, however much we may desire to, because that is not the mood in this generation and this Continent. I do have the hope that, in the professional schools themselves, we may have men of culture as teachers, men with a background of humanism, men who know their own subjects, simply as a part of the wide field of knowledge and know a considerable amount about that wide field of knowledge. I do not care what subject they teach. It will be culture whether it be civil engineering or anything else. As I see students today, many of them come to those wider things through their professional studies, if wisely directed. When they see the importance of their own field, they see its inter-relation to other things and through that widened interest they become more cultured. That may be the way, after all, that humanism will come.

To come back to the question of the scientist. The scientist as a rule believes that he is better as a scientist, as an expert giving his judgment to the statesman and then permitting the statesman to use that judgment as far as he can in the light of the conditions about which the scientist is not concerned at all. He may remain more powerful, generally speaking, as the man who gives the truth to those who have to put that truth into practice.

For instance, I have seen, in a Western University, all the members of a Cabinet sitting in with the staff in Soil Survey, who had explored northern territory by soil reconnaissance, to get the facts about that new territory, in order from those facts to develop their policy of settlement which was the function of the government. That, to me, seems to be the sound relationship; the scientist giving the facts of the case; the men who are responsible for policy putting them into effect, as far as it may be possible. I have a feeling that more and more the physical and biological scientist will sit in with the historians and the economists and the sociologists on joint problems where all are needed in order to get at the sound picture they are studying. I think that joint co-operative work is going to be one of the natural functions of men of science and the social workers for the future.

To take an illustration which I happen to know fairly well. It was found possible to study in a very detailed way a pioneer area. That area was Western Canada, the prairies. This was made possible through the good offices of the Social Science Research Council of the United States and the American Geographical Society and the co-operation of several Canadian scientists and social workers. Studying this problem of the settlement of the West there had to sit together the historian, the economist, the sociologist, the soil man, the climatologist, the geologist—at least that group—before it was possible to get a picture that was adequate. These men sat in conference again and again in order to develop a picture representing first of all the physical background; secondly its effect on the people who came in; thirdly, the way it attracted the people to the various sections, and, fourthly, the way they disposed themselvs and reacted sociologically, as a result of the background of climate and soil and weather conditions generally. I have seen that work carried through to a very successful conclusion. As a result there has been published a series of volumes that stand alone in the world as a study of a pioneering belt, one of the latest of the pioneering belts.

I believe that the time is past when we can do our best work by considering our own field alone, because by so doing we become lop-sided and without an appreciation of truth in its universal aspect. It is necessary for us, not to work in other fields because we would be useless there, but to sit in with those who are competent in the other fields and discuss the problems together in the wide universality of truth. That, I think, is the disposition of the future. We all realize that the social fields of study are going to become much more important. We cannot now use science to the fullest advantage of the world, because we do not know man well enough. If we knew man better, the results of science could be used more soundly.

Why is it, for instance, that we blame scientists for turning their ability to the making of armaments? Without the scientists it could not be done, because new devices have constantly to be put into effect. It is not because the scienists are non-moral. It is because we do not yet know what is the best thing to do, because we have not yet been able to analyze to the foundations the causes of war; indeed, because we are afraid to analyze them. In doing so, the sacrifices each of us will have to make as nations will be greater than we can yet contemplate. We now know imperfectly that war will not stop except through great sacrifice on the part of every nation. We are just a little unwilling to probe deeply enough to see how great the sacrifices have to be to us. Only when we can do so will science be rid of the criticism that is thrown at it today, that it is using its power wrongly, that it is not using its power to the best advantage of man, unquestionably, as far as civilization and its amenities are concerned.

I am not one of those, however, who feel that necessarily man is much the better because of science. More comfortable, yes; an easier life, yes. But as far as standards in the things that matter, I am not quite so sure. I can think of the time in the rural community when the farmer had to take three hours to get to the market twelve miles away, because he used the old working farm horse to get there. He took a whole day. Now, he can do all the work in a couple of hours, at the longest, and has all the rest of the day. But I think of that rural community and its mental and intellectual qualities, because I knew it well, and I am not at all sure that the advent of the motorcar or of other scientific devices has raised people in rural communities higher than they were in those days. It is the deeper test that we must apply. We will not

really make progress as we should until the sciences, correctly so-called, and the social studies, join hands in order to get at the real issues. Even then progress will be slow. It is now thirty or forty thousand years since man was able to draw, in those caves in Southern France and Northern Spain, the animals of the chase in a way, both in drawing and in colour, which can stand comparison with some of the things we see today. And when some people are enthusiastic enough to speak of the Utopias that will come with this or that particular system, those of us who are in the scientific field and who have perspective, at least of the past, should be the people to hold the balance and say, "No, it may be that will mean progress but it will be very, very slow, because it is the human race that has to carry it through and the human race is still imperfect and will not respond as fully as you think it will. That is the best that can be done. It is much for us all together to face in the direction where we think the truth is."

Let the sun of the morning shine in our faces and let us not concern ourselves so very much that, in our own little life-time, the steps we have taken are so few. If they are in the right direction, some day, when your children's children's children's children have had a chance to look at it, it may be possible to see that real progress has finally been made.

We are facing the facts of the human race and its background should be the people, it seems to me, who act as the balancing wheel when those Utopias are flaunted before us and each new generation, as it always has done, sees a Paradise in the immediate future. Eventually it may be, we trust it will be, that if we keep hand in hand in the work I have been discussing, as workers together, some day the vision of the poet will come true that

> Man and his littleness perish,
> Erased like an error and cancelled;
> Man and his greatness survive,
> Lost in the greatness of God.

THE SCIENCE OF MAN

EDWARD SAPIR

In this lecture, Dr. Sapir pointed out how dangerously unaware we are of values in cultures other than our own, and, in a brilliant lecture, developed the thesis of the reality of culture in all the different groups of man. He suggested that, if the nobility of culture and its nuclear value could be made the approach to the study of history, we would develop a mutual tolerance throughout the world, based on mutual respect and understanding. While he realized that this called for a teaching staff which could actually transcend prejudice if the whole venture were not to degenerate into dangerous sentimentalism, he felt the objectives of liberation from prejudice and of a new tolerance were well worth the effort.

PROCEEDINGS

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FOREWORD

The following summaries of the lectures held under the auspices of the Royal Canadian Institute during the Session 1937-1938 have been prepared in order to make available to our members a permanent record of the many diverse and frequently novel subjects discussed by the distinguished authorities who have generously contributed to this lecture series.

We are indebted to Mr. E. J. Torres for the preparation of many of the abstracts made from his verbatim reports and we are also grateful for the co-operation offered by the lecturers in reading the copy submitted. Six of the lecturers prepared their own summaries and for their interest and assistance we are deeply grateful.

E. M. W.

CONTENTS

"PRESIDENTIAL PEREGRINATIONS TO THE PACIFIC"

J. Ellis Thomson

This lecture described the details of a trip to the west and return for the purpose of visiting several educational institutions in Canada and the United States in order to obtain some idea of what research was being carried out in the mineralogical laboratories at these institutions; what equipment was being used; and how their housing compared with our own in the University of Toronto. The journey to the west coast was made with the special tour of the Canadian Institute of Chemistry with brief stays at Copper Cliff, Kimberley, and Traill to inspect the mining and metallurgical plants of these places.

After three days in Vancouver where the University of British Columbia was visited, travel was first by boat to Victoria and Seattle and then by train to San Francisco. The University of California at Berkeley and Stanford University at Palo Alto were next visited, the lecturer being especially impressed with the beautiful buildings on the campus of Stanford University.

On the return trip, after a charming four-day tour in Yellowstone Park, the Colorado School of Mines at Golden, the University of Wisconsin at Madison, and the University of Michigan at Ann Arbor were visited in turn. The lecture was illustrated with coloured lantern slides.

"BY AIRPLANE TO PYGMYLAND"

M. W. Stirling

During 1925-1926, Mr. Stirling conducted a co-operative expedition into Netherland New Guinea under the combined auspices of the Smithsonian Institution and the Indian Committee for Scientific Research of Batavia, Java. New Guinea, the second largest island of the world, is to-day the least known of any section of equal size on the habitable globe.

The objective of the expedition was the central portion of the Nassau Mountains lying to the north of the Carstenz Top, where a large group of Negritos was discovered and ethnological studies made of them. Several tribes of Papuans were also briefly studied.

The total personnel of the expedition was more than four hundred, consisting of Dyaks, Malay convicts, and native Ambonese soldiers, in addition to the Europeans and Americans. An interesting feature of the expedition was the use of an airplane for reconnaissance purposes and for freighting supplies. The large ethnological collection brought back to America is now in the U.S. National Museum.

There were 25,000 feet of motion picture film taken, from which 5,000 feet were selected for the lecture film.

Approximately a year and a half was taken in preparation for the expedition.

"TRANSMUTATION"

K. K. Darrow

The lecturer reviewed the career of the late Sir Ernest Rutherford, in his opinion "the greatest figure in the history of the recent art of the conversion of the elements."

Transmutation is the conversion of the elements, almost always two by two. An element, in this instance, is any substance which retained its identity despite the efforts of our predecessors to change it with the means at their disposal: temperatures which rivalled those of the sun; pressure thousands of times that of the atmosphere; chemicals of violent corrosive action; electrical charges; powerful beams of light; and, in the early years of the twentieth century, x-rays, electron streams, gamma-rays, and other strange and potent agents.

The elements, which differ in many physical respects, may be reduced to a common denominator—the atom. The positively-charged nucleus of the atom (in which most of its mass is concentrated) is surrounded by negatively-charged satellite electrons. The whole is electrically neutral. The number of electrons, or conversely the charge on the nucleus, is constant for any given element. The hydrogen atom has one electron and a nuclear charge of plus one; the most massive of the known elements has 92 electrons and a nuclear charge of plus 92. There are three types of hydrogen atom, each with a nuclear charge of plus one and one satellite electron and nuclear masses in the ratio of 1 : 2 : 3. We call such atoms isotopes of one another; some elements have as many as eleven isotopes.

Almost all the elements have been transmuted, several in many different ways. The second isotope of hydrogen has been transmuted into the other two isotopes of hydrogen;

hydrogen plus oxygen into nitrogen and helium; hydrogen plus lithium into helium.

The principle of conservation of mass holds in transmutation. Nitrogen (14) plus helium (4) are converted into oxygen (17) plus hydrogen (1).

Wherein does transmutation differ from the ordinary chemical reaction? Lithium, when exposed to hydrogen, is covered with a layer of lithium hydride. The hydrogen atoms are linked to the lithium atoms, but the nuclei have preserved their identity. The ultimate natures of the nuclei concerned remain exactly as before. A chemical reaction is no more than that.

In transmutation the two nuclei fuse and explode into new-born nuclei of another sort. The positively-charged nuclei repel each other; they must be driven into contact. When it became possible to bombard "target" nuclei with "bullet" nuclei which moved with an energy of eight million electron volts, transmutation was achieved. A shell fired from such a gun as "Big Bertha" is, in all likelihood, the fastest-moving piece of tangible matter ever placed in motion by human agency; the atoms of such a shell have an energy of approximately one electron-volt. Our predecessors who attempted transmutation by ordinary means were in the position of a child who attempts to throw a ball over Mount Everest.

The four energized nuclei commonly used as "bullet" nuclei are the proton, the deuteron, the neutron, and the alpha particle. The first two are the nuclei of the isotopes of hydrogen with masses one and two respectively. The neutron we shall discuss later. The alpha particle is derived directly from radium already endowed with the tremendous energy of eight million electron-volts. Rutherford, while Professor of Physics at McGill University, conceived the idea that it might be used to effect transmutation, and in 1919 he succeeded in transmuting 14 elements.

Later he suggested that, if other nuclei be energized artificially they might be used. In 1932 free hydrogen nuclei

were endowed with the requisite energy by means of high voltage machines, and conversion was achieved in observable quantity by nuclei carrying the relatively low energy of 100,000, or even less. Transmutation by these artificially energized nuclei soon became more plentiful than that by alpha particles.

Of the many machines used to impart energy to nuclei, two are remarkable for their novelty and power: that devised by R. J. Vande Graaff of Princeton and the Massachusetts Institute of Technology, and utilized by several physicists; and the "cyclotron", invented and developed by E. O. Lawrence of the University of California and copied by multitudes of others, which can load nuclei with 10,000,000 electron-volts or more, though the actual voltage in the machine may never exceed 50,000.

The day when we shall produce bricks of new gold or fill airships with new helium is still in the unforeseeable future. Conversion has been produced only on a very minute scale, and extremely special methods must be used to detect it, the most outstanding of which is the Wilson chamber or expansion chamber method. It is a glass box with a piston at one end. When the piston is pulled out, the imprisoned air expands and its temperature drops. If it drops below the dew-point, the water vapour will condense on the dust in the air; if the dust is removed by filtration, the water vapour will remain in suspension. When "bullet" nuclei are shot through the chamber, they tear electrons away from the oxygen and nitrogen atoms, and positively-charged oxygen and nitrogen nuclei are left to wander through the gas. The water vapour will accept these charged nuclei as a basis for condensation, and they are visible as a filament of fog. By an exhaustive study of Wilson chamber phenomena, physicists have been able to determine the facts of transmutation.

The most important of the transmuting nuclei is the neutron—discovered in 1932. If "target" deuterons are bombarded by energized deuterons, there occurs a process in

which two interacting particles combine and then explode, the fragments of such an explosion being a "helium 3" nucleus (mass three, charge two) and a neutron (mass one, charge zero). The neutron carries no charge whatsoever, and consequently does not share the disability of the ordinary charged nuclei when it is used for transmutation. It can slip into other nuclei; the door is not locked against it. To-day the neutron is the most powerful transmuting agency we have. Already about 400 transmutations stand to its credit.

Many of the nuclei produced by neutron transmutation are of types which have never before been observed; and most of these new nuclei are unstable,—they sustain themselves for a time, and collapse. The fact that they eject electrons of high energy is of tremendous importance, and their scientific and medical value may well prove immense. Conversely these unstable or radio-active nuclei are every bit as dangerous as those of natural radio-active substances, and workers must be protected against them, just as they have to be protected against the energized nuclei which are used to effect transmutation.

These artificial radio-active substances are outstanding examples of nuclei fashioned by man himself. The world takes for granted the creation of new breeds of plants and animals by the biologist; of new chemical compounds by the chemist; of new manifestations of energy by the physicist; of new machines by the engineer. Now it is destined, in the fourth decade of the twentieth century, to discover man in a new role—the creator of new elements.

"SEEING THE UNSEEN WITH HIGH-SPEED PHOTOGRAPHY"

HAROLD E. EDGERTON

The stroboscope and the high-speed motion picture camera are research instruments which enable one to "see" actions that are too fast for the unaided eye to examine. The actions are apparently slowed down, permitting the observer to study them in detail.

The stroboscope (literally: whirling-watcher) is an instrument which makes it possible by intermittent illumination to watch rotating or vibrating objects. The flashes of light are controlled so that they occur at intervals of time corresponding to the interval of time for one revolution or vibration. In this manner the eye sees the object that is under observation at the same place in each revolution, and the eye holds over the successive images by means of the persistence of vision. Should the frequency of the flashes of light be slightly faster or slower, then the object will appear to rotate backward or forward at a slow rate, corresponding to the difference frequency. Thus by means of the stroboscope a rapidly-moving machine may be made to go at an apparently slow rate of speed, and the eye is able to follow the motion. The stroboscope therefore finds extensive use in experimental laboratories where machinery is being developed.

The speed of a rotating object is easily determined by the stroboscope, since the frequency of the flashes and the speed of rotation correspond when the object appears stationary. The advantage of the stroboscope for this purpose is the fact that no mechanical connection to the rotating object is needed. This becomes of paramount importance for cases involving inaccessible shafts and light, small or delicate parts which would be greatly retarded if they were required to drive a speed counter of conventional design.

The usefulness of the stroboscope is limited to problems involving periodic motions fast enough so that the persistence of vision holds over the successive images. Many problems do not meet these requirements, and it is here that the high-speed motion pictures taken at a high rate of speed and then projected normally show the motion reduced. The greater the speed of the camera, the slower the speed of the action on the screen.

The ordinary type of motion picture camera with its shutter and intermittent motion can be sped up only to about ten times its normal rate before the operation is limited by the strength of the film. Cameras operating at speeds higher than are possible with the intermittent motion must use *continuously-moving* film. However, even if the film does not stop, the image cast by the lens must be stationary with respect to the film during the exposure time, in order to prevent a blurred photograph.

In general, there are two methods of accomplishing this: First, by utilizing a moving optical system; and secondly, by using very bright flashes of light that are so extremely short that no appreciable motion between the image and the moving film is apparent. Examples of the first method are rotating lenses, rotating multi-sided mirrors, and rotating prism arrangements.

The second method, involving very accurate control of the source of illumination, is useful for taking single photographs of rapidly-moving objects, with ordinary still cameras as well as taking high-speed motion pictures.

Electrical methods are used almost exclusively for producing short intense flashes of light suitable for this second type of photographic work. The flashes are produced when electrical charge that has been accumulated in a condenser is suddenly released through a spark gap or a gas-filled discharge tube. The duration of the flashes is determined by the dimensions of the circuit, and by the afterglow of the gas in the discharge. Weak sparks can be made to give an ex-

posure as short as 1/1,000,000 of a second, while more powerful ones have a main peak of illumination lasting several millionths of a second, followed by an afterglow which may last as long as 1/100,000 of a second.

One of the most serious problems is the control of the instant of flashing; for example, in order to photograph the maximum compression of a golf ball under impact from a club, the timing must be accurate to approximately 1/50,000 of a second, since the entire compression is made in about 1/10,000 of a second.

High speed photography permits the observer to obtain a picture or a series of pictures accurately recorded as a function of time, permitting detailed study of the action. The pictures of a series may be analyzed frame-by-frame, or they may be projected on the screen in ultra-slow motion, permitting the eye to see vagrant actions that are normally imperceptible. The high speed camera (because of its directness and clarity) is one of the best methods of motion analysis.

High speed photography is a very complex subject and therefore cannot be discussed in detail in this abstract. For those who wish to look up the original descriptions, a fairly complete bibliography of the subject may be found on p. 153 of the February, 1935, issue of Electrical Engineering, a publication of the American Institute of Electrical Engineers.

"THE TRANS-CANADA AIRWAY"

J. A. Wilson

Critics notwithstanding, Canadian aviation had measured up to its opportunities, said Mr. Wilson. At the close of the war, other countries had been forced to develop inter-city lines as an adjunct to military defence, whereas Canadian aviation had worked to promote forestry, surveying and mining in our hinterland. No country in the world has received so great a return from its aviation dollar; and we have the largest self-sustaining aviation system in the world.

In 1928 American transcontinental air lines began to tap Canadian traffic by north and south lines across the border. While these connections were welcome it was not in the public interest that there should be no east and west connection by air in Canada and our government authorized surveys for a trans-Canada airway. The prairie section presented the easiest problem and work was begun there the next year. On March 1, 1930, flying operations which proved satisfactory were begun in that section and also between Moncton, Montreal, Toronto and Windsor. Budget difficulties consequent to the depression forced temporary suspension of these services on March 31, 1932, though the trans-Canada surveys were continued.

In 1933 the urgent need to provide employment for single homeless men lead the government to absorb such unemployed in airway construction work in Northern Ontario and British Columbia. On June 30, 1936, the relief camps were closed and the work was continued by day labour, contract and machinery.

Natural conditions divide the trans-Canada route into four distinct regions—the Rocky Mountain region, the Prairies, the Laurentian (or Northern Ontario) region, and the St. Lawrence-Maritime area. The airway links Vancouver, Leth-

bridge, Calgary, Edmonton, Regina, Winnipeg, North Bay, Toronto, Ottawa, Montreal and Moncton, while connections with all important cities off this route will be instituted.

The Laurentian district—one thousand miles of sheer forest, rock and lake—was the most difficult section. A route well to the north of Lake Superior was selected as the most practicable.

In the St. Lawrence district, suitable sites were easily found, but in the Maritimes the rough terrain complicated the problem.

The aerodromes are spaced at approximately forty miles; wider in level, open country, closer in the mountains and Northern Ontario. Terminal cities on the route are asked to provide a minimum of three graded runways 3000′ x 300′, capable of extension to 5000′ x 500′. The intermediate aerodromes have three runways 3000′ x 300′, though in some cases two will suffice for the present. In the mountains, since the winds blow either up or down the valley, one strip 3000′ x 500′ will serve.

Drainage (if necessary), adequate lighting, two-way radio contact, meteorological service, and radio range beacons (to keep the pilot on his line of flight) have been installed.

The Trans-Canada Airlines Corporation, established in 1927 by Act of Parliament, has been organized to operate the lines. Regular service between Vancouver and Montreal should materialize by mid-summer, 1938; the Atlantic section should be ready by the close of another construction season.

Toronto is more than a terminal; very centrally located, it is the most important mailing centre in Canada. Having delayed construction of a civic airport, she is now in a position to profit from the experience of other communities.

The Island site has two runways, both clear of obstruction from high buildings; one is approached from the south, over the lake, the other from the Western Channel, over park lands. Despite its many obvious and unique advantages, this site

calls for an auxiliary airport, because the proximity of tall buildings inhibits its use in bad weather.

The auxiliary aerodrome, located at Malton on a city-owned plot of 1600 acres—more than adequate to meet expansion—ensures a clear approach from the air in bad weather. Development of this site has been very rapid, as much labour-saving machinery has been used.

The trans-Canada airway is an important link in the world's airway system. The shortest airways between North America and both Europe and Asia pass through Canadian territory, and our co-operation is necessary for their efficient development.

The North Atlantic trade route is perhaps the most important in the world. It joins the greatest centres of population and industry of the Old and New Worlds. The eastern and Western terminals of the direct trans-Atlantic airway lie within the British Commonwealth, and from the earliest days of aviation the Canadian Government has watched its development with growing interest.

The length of the ocean crossing and the climatic difficulties have delayed the establishment of any regular service by this route, but, with the advance of aeronautical and radio science and improved meteorological services, these are being conquered.

In December, 1935, the Governments of Canada, the United Kingdom, the Irish Free State and Newfoundland agreed to co-operate in establishing a regular air mail, passenger and express service across the Atlantic. Later the United States Government subscribed to the scheme.

The practical results of these two conferences are the trial flights which have been made by aircraft of Imperial Airways and Pan-American Airways during the past summer. The uninterrupted success of these trial flights and their regularity inspire confidence that in a relatively short time commercial trans-Atlantic services will be in operation.

The Pacific crossing is not of the same urgency or import-

ance as the Atlantic crossing and has not received the same attention from Canada. For over a year, however, Pan-American Airways have operated a regular weekly air mail, passenger and express service from San Francisco to Manila, via Honolulu.

The most direct route to the Orient is, however, by northwestern Canada and Alaska, across the Bering Straits to Siberia. Unsettled political conditions in northeastern Asia have, up to the present, made its development impossible; but the extension of European air lines to the Far East will greatly affect North American lines of communication and will, before many years have passed, force this route into prominence for the protection of Canadian and American interests in trans-Pacific commerce.

The whole North American section of the Northern Route to Asia is already under regular operation. It only requires further aids to air navigation to make it capable of high speed operation at all seasons of the year. When settled political conditions prevail once more in eastern Asia, this route will come rapidly into prominence, as it is much shorter than the Honolulu route and has not the disadvantage of the long uneconomical ocean flights.

When Canada's transcontinental airway is completed, the advantages of her northern position in the world's airway system will be manifest. It connects with the shortest route across the Atlantic, and Trans-Canada Air Lines, the national operating company, will be a direct participant in the trans-Atlantic operation. Through efficient north and south connections in the maritime provinces, at Montreal, Toronto, Windsor, Winnipeg, Lethbridge and Vancouver, the system will give ready access to southbound traffic over the United States system and the airways to Central and South America. Air commerce for North America from the European, African, Asian and Australasian systems will pass by the direct route across the Atlantic, through Canadian terminals, and thence to all points in Canada and, in addition, to points in southern,

central and western United States. Through a system of feeder lines, it will serve the few important cities not now on the main line and also connect with the immense traffic now handled by existing services to the northern mining areas, which are to-day the greatest non-subsidized air traffic systems in the world. Through its connections on the Pacific coast it has access to the existing trans-Pacific service to eastern Asia and New Zealand, and already the North American section of the direct airway of the future to the Far East is well established. With these advantages, a bright future seems assured to Trans-Canada Air Lines.

Canada's railways, her steamship services on the Atlantic and Pacific, telegraph and telephone services and radio have a world-wide reputation for high standards of service. They have all been pioneered by Canadians and Canadians can be depended upon to duplicate the same leadership in the air.

"FROM ROCKS TO DOLLARS"

H. E. T. Haultain

During the year 1936, agriculture contributed $745,000,000 to our national income; mining, $362,000,000; and our forests, $215,000,000.

Since the time at my disposal precludes a more detailed examination, I shall confine my remarks to the gold ores which are treated by forty-odd mines in this Province, and the ores in the Sudbury district which yield nickel, copper and platinum. In 1936, production of metals in Ontario totalled $165,000,000: gold, $80,000,000; nickel, copper and platinum, $81,000,000; silver, lead, molybdenum, etc., $4,000,000.

These metals are brought to the surface encased in twelve and a half million tons of hard rock which differs but little in appearance from the rest of the rock in this country. This rock we call "ore", and, though this word is used so frequently, we have no satisfactory definition of the term. The metal recovered from this ore is exchanged for a few pieces of paper, bank cheques, which economists assure us represent $165,000,000. If we press them for a definition of the word "dollar" they prove rather evasive, and when cornered are compelled to admit that "dollar" is as poorly defined as "ore".

To-night I am attempting, in the simplest of outlines, to describe some of the processes between the breaking of the ore from its original place to the receipt of the cheque. The gold-bearing ores are treated differently from the base metal ores, which yield nickel, copper and the platinum group of metals. Each year we treat 8,000,000 tons of gold ore and, though we may occasionally see a high grade specimen, by far the greatest amount of our gold is obtained from ore in which no gold can be seen with the naked eye nor, in many cases, with a microscope. The main difficulties of recovery lie with these minute particles—in the majority of the cases they pay the dividends.

The rock is broken underground by dynamite and brought to the surface mostly in large pieces, which are crushed by giant "nut-crackers", as easily as we crush a walnut. The pieces from these crushers are then ground with water in ball mills to an impalpable powder. When the gold is relatively coarse, say the size of a small pinhead, it is easily recovered. At the Dome 70% of the gold is recovered by the simplest metallurgical process known to men. The finely ground ore and water, which is known as pulp, flows over sloping tables covered with corduroy and the gold is caught between the ridges of the corduroy.

In the Kirkland Lake district, the pulp must be stirred with a gold solvent—a very dilute solution of sodium cyanide. This process, introduced at the end of the last century, has been improved by constant research. The mixture is agitated by huge paddles, or by blowing air through the mixture, or by a combination of the two. After 48 hours agitation, about 95% of the gold is in solution which may contain four to five dollars worth of gold per ton of solution. The problem of getting this solution away from the finely divided ore is one of the difficult problems. It is achieved either by settling, followed by decantation, repeated several times with intermediate washing, or by filters. The difficulty lies in the enormous area of rock surface that is wetted by the gold-bearing solution. The Lake Shore mill alone makes 250 square miles of new rock surface every day. Despite all the technical skill, a few cents' worth of dissolved gold remains attached to each ton of the tailings, as the final waste product is called. The disposal of 8,000,000 tons a year of these tailings is another probem for the engineer.

The gold-bearing solution, after separation from the rock, is stirred with very finely divided zinc upon which the gold is precipitated. Filtering recovers the gold as a dirty brown powder, which is subsequently melted and refined. The end product is a brick of gold, containing some silver, which is sent to the Mint at Ottawa and, in due course, the company

receives a cheque. The gold bricks are carefully stored away, with most elaborate precautions to guard them. Apparently the only thing that is done with them is to move them about from time to time, or else to put different tags upon them. Figure that out. I hope you can. I never could. The world does not seem able to get along without this gold in storage.

Described in this way, the extraction of gold seems simple enough, but in reality many complications continually beset the process, and experiment and research are continually being carried on.

The treatment of our copper-nickel ores is much more complex. The crushed ore is submitted to a froth flotation process in which air is forced through the pulp in minute bubbles, bringing to the surface the valuable sulphide minerals adhering to the bubbles in a froth. The waste minerals are drawn off from the bottom of the apparatus. The valuable minerals are then subjected to complex processes of roasting and smelting, followed again by various refining processes—electrolytic and otherwise. The final results are pure nickel, pure copper, pure platinum and palladium, and other precious metals, all derived from the one basic ore.

Mining engineers are constantly striving to perfect their methods. At the Department of Mines and Resources at Ottawa, we have the largest ore-testing laboratories in the world, staffed by men who command an international reputation.

In closing this brief description I cannot refrain from mentioning a trend which is to me very significant. More and more engineers are becoming superintendents, managers, general managers, presidents. More are serving on directorates; more are organizing and financing their own companies. In short, more engineers are assuming positions of financial trust. For this the engineer has an outstanding quality. He is bred to a great tradition, the scientific respect for truth. To deal with the forces of nature, he must be honest. He cannot fool nature if he wants to get results.

When he enters other branches of the industry, he keeps that same persistent honesty with him. As a financier he is honourable towards the public. In the position of management he is honourable towards labour. Mining men the world over have observed and commented on this healthy trend in Canadian mining. To me it is the most significant feature of the industry to-day.

"ANTARCTIC GEOLOGICAL ADVENTURES"

LAURENCE M. GOULD

Dr. Gould was geographer and geologist of the Byrd Antarctic Expeditions in 1928-30 and 1933-35. A geological party visited the Rockefeller mountains, 140 miles east of Little America, the headquarters of the expedition. They are a group of low-lying scattered peaks and ridges almost completely covered with snow. The rock is quite barren of interesting or important mineralization. The main body of rock is a coarse-grained pink granite. In sheltered places bits of lichens and a greenish mosslike growth were found. Evidence was found of a good deal of melting about the mountains during the summer months. The mountains are not primarily due to tectonic disturbance; they are peaks and ridges of circumvallation, caused by the erosion of the surrounding materials.

On November 4, 1929, a party of six left on a 1500 mile sledge journey to the Queen Maud Mountains and return. This mountain range is situated 350 miles from the pole. It is a dangerous journey for the route is beset by numerous crevasses.

The Queen Maud Mountains are a great array of ragged, irregular and rather low-lying peaks backed up by great tabular mountain masses that tower far above them. The party ascended Mount Fridtjof Nansen, and gained much geological knowledge of the area.

On the return journey they substantiated Commander (now Rear-Admiral) Byrd's discovery of "Marie Byrd Land" which he had claimed from the air. On Christmas Day the expedition accidentally stumbled on the cairn left on Mount Betty by Amundsen 18 years earlier when he was northward bound for Franheim from the pole.

The most distinctive of Antarctic glacial features is the Ross Shelf Ice. Discovered in 1840 by Sir James Clark Ross, it extends as a dazzling white cliff for over five hundred miles in an east-west direction roughly in latitude 78 degrees south. It is the boundary of the southern navigable limits of the Ross Sea. This great sheet of ice covers a quarter of a million square miles. Because of the ice flow, the contour of the ice continually changes over a period of years. There is a top crust of three or four feet of ordinary snow, and from there to sea level it is made up of granular snow.

"MAN AND HIS MICROBES"

G. B. Reed

Man has probably always been in controversy with his microbes. Between the years 1860 and 1880 the primary work of Pasteur, Lister and Koch laid the groundwork of our present knowledge of the relationship of microbes to man. We now know that a large proportion of all the illnesses of man is due to the growth and activity of microbes in the body. We also know that the increase in duration of life from some twenty years in the Roman period to almost sixty years at the present time is in large measure the result of increasing knowledge and control of these microbes.

Typhoid fever provides a striking example of this knowledge and control. During the 18th century the death rate from typhoid was enormous. In England and Wales in this period it amounted to 50 to 60 deaths per 100,000. From about 1870 to the present time there has been a conspicuous decrease in mortality; a period of gradual decrease between 1860 to 1870 down to 1890 to 1900, and a period of rapid decrease from 1890 or 1900 to the present time. These two periods of decrease in mortality may be associated with the state of knowledge. The first corresponds to a growing awareness of the value of sanitation. The second period of precipitous decrease corresponds to positive knowledge of the causal agent beginning with Eberth's discovery of the microbe in 1880. It was shown that the disease results from the growth of this organism in the tissues; that the organism leaves the body in the excreta, reaches water supplies through sewage and causes new infections through the consumption of contaminated water. The now familiar procedures of sewage disposal and water purification are based upon this knowledge. The history of Cleveland is characteristic of many cities—from 1875 to 1904 the typhoid death rate ranged around 50

per 100,000. In the latter year a change in the position of the water intake was followed by a marked typhoid decrease. In 1910 chlorination of the water was introduced as a means of killing typhoid bacilli, and resulted in a further decrease to 10 typhoid deaths per 100,000 and in 1917 filtration and chlorination was begun resulting in a decrease to 0.5 typhoid deaths per 100,000.

Here then is an example of a disease microbe which has been nearly conquered, but it must be remembered that the ground gained is only held by eternal vigilance.

On the other side of the picture tuberculosis provides an example of a microbic disease concerning which positive knowledge has been less successfully applied. Beginning with the work of Robert Koch between 1888 and 1890 we know that the two chief methods of distribution of this organism are directly from person to person, or in the case of the bovine type, from cow to child. In the former case the person suffering from pulmonary tuberculosis discharges the causal bacilli in the sputum, frequently in very large numbers. The semi-fluid sputum may be dealt with fairly successfully, but such a patient discharges, in the act of sneezing or even talking, a spray of moisture droplets which is frequently heavily laden with microbes. This is the problem which confronts us in the case of all infections of the respiratory system.

It has been amply demonstrated that the chief source of infection is not the chance contact with a blast of microbe laden spray but the continued day to day contact. Opie has just advanced new evidence to the effect that it is primarily a matter of family contact, pointing directly, therefore, to the necessity of isolation of the open lesion cases.

The problem of childhood infection with the bovine type of organism in raw milk from tuberculous cows can be solved, we now know, by pasteurization.

Quite as effective as the source of infection are the factors which promote development of the disease. There is ample evidence from all parts of the world, including Canada, to

indicate that chief of these predisposing factors is overcrowding, inadequate housing and undernutrition.

Forty years of intensive study of this microbe has, therefore, failed, except in the case of the bovine variety, to provide us with the means of direct combat. It has shown us however that effective control may be realized by (*a*) the isolation of open lesion cases, and (*b*) the maintenance of a decent standard of living. These are largely matters of economics. The failure to give effect to these measures is responsible for the continuing high tuberculosis rate.

These are merely two examples taken from near the extremes of our knowledge of man and his microbes. Forty to fifty years of increasing knowledge has shown the way to control or eliminate certain microbes. In other instances the information is effectively used in the upper economic levels, it is less effectively used in the lower economic levels. Our knowledge of a long list of microbes more or less falls between these two examples. In other instances our knowledge is much less or is even negligible.

"WILD FLOWERS OF THE CANADIAN ROCKIES"

MRS. MARY VAUX WALCOTT

Over a period of fifty years Mrs. Walcott visited the Canadian Rockies 45 times, in order to paint and study the wild flowers of that region. She and her husband, a geologist, for many years made their headquarters on the shores of Lake Louise, from whence they journeyed westward into the mountains. The flora of the two ranges, the Selkirk and the Rockies, have not a great deal in common; once the line of the Columbia River is crossed, the flowers are in many instances altogether different. The flowers live and die within a period of eight weeks, since few are to be found after the first snow comes, in mid-August.

She ventured the suggestion that many of these hardy flowers could not be successfully grown outside their habitat unless the exact environment were duplicated. She found, too, that altitude and latitude seem at times to be synonymous: When she first began work on the plants from New England, those which came from the far north seemed to possess the same characteristics as those found in the Canadian Rockies at a much greater altitude.

Gifted with an acute sense of colour, colour photography of wild flowers she considers a definitely unsatisfactory medium. Her flower paintings are executed with transparent water colours. She has many photographs of flowers taken under very difficult and trying conditions in the field.

The flowers discussed were: the lemon columbine, primrose, cottongrass, tumblegrass, heliotrope, valerian, painter's brush, forget-me-not, anemone, zygadenus, elk's lily, violets, orchids, Labrador tea, bunchberry, dogwood, clematis, dandelion, devil's club, rhododendron, *Linnaea americana*—a flower of surpassing fragrance, rare saxifrages—which grows at an elevation of 11,000 feet, just where the melting snow can trickle

down to nourish their roots, the avalanche lilies—which grow up through the snow (she has never been able to find out what wakens them in the spring), and the rock cress—which is sometimes termed a heather, though it is a plant of different family.

"AERIAL PHOTOGRAPHIC SURVEYING"

K. B. Jackson

Surveying may be defined as the process of determining and describing the relative positions of things, and therefore involves the making of measurements and maps or, perhaps, only photographs. In photographic surveying the transit or plane table is replaced by the camera, which records on its sensitive plate or film almost an infinite number of "observations" in a fraction of a second; and in aerial photographic surveying the aeroplane provides easier and infinitely faster transportation to better, though less well-defined, points of view.

Two advantages of these modifications are obvious: an increase in the amount of information obtainable and an enormous decrease in the time required to obtain it. It is not immediately apparent, however, what precautions must be taken to assure sufficient accuracy in the interpretation of that information. For example, the relative position of the lens and plate or film in a surveying camera must be accurately determined and kept constant. The location and orientation of the camera at the time of exposure must be known; and the nature and extent of distortion in the photograph, due to the lens, camera orientation, film shrinkage, or configuration of the terrain, must be appreciated.

The purpose of a photographic survey and the nature of the terrain will determine the method of procedure to be adopted—whether terrestrial or aerial photographs are more useful, whether the photographs themselves are sufficient, or planimetric or contour maps are necessary.

In Canada terrestrial photographic surveying had been developed long before aerial methods were possible, and is still used for mapping the mountainous regions in British Columbia and Alberta. A sufficient number of camera

stations are located by the usual instrumental methods; photographs are taken on infra-red plates (which yield much clearer detail in the distance); enlargements are made from these plates; and the necessary measurements obtained from them with the aid of instruments designed for the purpose. By this means the position of any point appearing in two different pictures may be located and, with a sufficient number of such points plotted, a contour map is constructed. Recently, aerial photographs have been used to provide the detail in the valley bottoms which is often hidden by the lower portions of the mountains on which the camera stations are located.

Before discussing the use of aerial photographs in surveying, it might be useful to consider the relative merits of a hill-top and an aeroplane as camera stations. The hill-top is stationary and its position can be easily determined. The camera can be accurately oriented and the time of exposure may be adjusted to suit the type of plate and filter that will give the best results. The horizontal photograph reveals differences in elevation to the best advantage, but a great deal of territory is hidden and must be photographed from elsewhere. Also, the hill-top camera station may be almost inaccessible. Whereas in each detail the reverse in some sense is true of the aeroplane camera station; speed and vibration necessitate short exposures, the location and orientation of the camera at the time of exposure is less certain if not indeterminate. Differences in elevation are less obvious, but there need be no hidden territory within the field of view. There is complete freedom in the choice of location, and transportation is easy and rapid. These differences make it necessary to use, and possible to transport, very different photographic and accessory equipment.

The standard aerial surveying camera used by the R.C.A.F. in Canada is equipped with a lens of 8¼ in. focal length, a maximum aperture of f/4, and shutter speeds of 1/50, 1/100, and 1/150 of a second. Over a hundred 7 x 9 in. negatives are obtained on a roll film loaded in an interchangeable magazine.

The photographs obtained may be classified according to the orientation of the camera as follows: High Obliques, in which the horizon is visible; Verticals, in which the camera is pointed vertically downwards; and an intermediate group, Low Obliques, which are used for the examination of forest growth, etc.

High Obliques are used for mapping the relatively flat lake-strewn areas of the North and West. Three cameras, supported on a single rigid mount, take pictures to the rear and at 45° to the right and left respectively. At a height of 8000 ft. the three cameras are exposed simultaneously every three miles in an east and west line of flight. The lines of flight are eight miles apart. Occasional north and south flights are made to strengthen the control in plotting. Thus each photograph yields eight square miles of plottable detail.

The detail in each photograph is plotted with the aid of a suitable transparent perspective grid superimposed on it. The grid is constructed to represent the appearance of a rectangular grid on the ground, had it existed at the time the picture was taken. The form of the grid depends upon the focal length of the lens in the camera, the altitude of the plane, and the position of the apparent horizon in the photograph. Obviously, a large number of these grids are required to take care of unavoidable variations in the altitude and tilt of the camera.

The detail in consecutive pictures and adjacent flights is co-related and adjusted to fit a sufficient number of control points (established by ground parties) to ensure the degree of accuracy required.

The method is applicable only to flat areas and the production of small-scale maps, but it is rapid and economical and has been used to map some 565,000 square miles in Canada to date.

Vertical photographs are used in the more settled areas, where a greater amount of detail and therefore a larger scale, and a higher degree of accuracy are required.

The same camera is used for Verticals as for Obliques in Canada, but the flying height is usually 10,000 ft. and sometimes 15,000 ft. The area covered by a single photograph, even at these heights, is very much less than in the Obliques; and, because it is necessary to obtain stereoscopic pairs of photographs of the whole area to make interpretation and mapping possible (involving an overlap of 60% in the line of flight and of 25% with adjacent flights), the plottable area per photograph at 10,000 ft. is only one square mile. Three modifications in camera equipment have been used to overcome this difficulty: the wide-angle camera, using shorter focal-length lenses; the multi-lens camera, obtaining simultaneously one vertical photograph and five or seven adjacent oblique photographs on a single film; and the multi-camera assembly, obtaining similar results on separate films. The first of these affords the simplest solution, as the other two require complicated printing apparatus to rectify the obliques.

In order to appreciate the difference between a single photograph and a stereoscopic pair, it is necessary, and sufficient, to see the latter. Several stereoscopic anaglyphs were projected on the screen. Two slides, made from consecutive negatives in flight, were projected by two lanterns equipped with red and blue filters respectively, and adjusted so that the images were partially superimposed on the screen. The audience was provided with red and blue filters, whereby the left (red) eye saw only the left (red) slide and similarly the right (blue) eye saw only the right (blue) slide, with the result that a three-dimensional model of the terrain was clearly perceived.

The first reason for taking vertical photographs that overlap 60% is now obvious: to provide for the stereoscopic examination of the photographs and so to perceive every variation of height in the terrain represented.

The second reason is to provide a means of plotting the detail obtained in the photographs, co-relating the photo-

graphs obtained in a flight, and producing a map of the area photographed, as described below.

A precisely vertical photograph of a perfectly level plain is an accurate plan of the area (ignoring lens distortion), to a scale determined by the flying height and the focal length of the lens. But in practice it is impossible to avoid variable tilts in the camera, variations in height of the plane, and, above all, variations in height of the landscape. These variations introduce distortions in the photographs when compared with true plans of the corresponding areas. But if the variations are within certain limits the distortions may be assumed to be towards or away from the centre of the picture or "principal point". That is, the distorted picture remains "angle-true" about the principal point. And on this assumption a method of triangulation known as radial line plotting may be used to plot the detail in a strip of pictures to a uniform scale—provided that each picture includes the "principal points" of the adjacent pictures. Obviously adjacent strips must also include common "tie points",—that is they must overlap. Hence the prescribed 60% overlap in flight and 25% overlap between strips provides for the above with a margin of safety to avoid gaps.

This method, in one form or another, is the one most commonly used in plotting from vertical photographs, and requires little more than a stereoscope and a careful draughtsman. (Over 200,000 square miles have been mapped in Canada from vertical photographs.) There are, however, many types of complicated plotting machines designed to increase the speed and improve the accuracy of plotting, such as Fourcade's Stereogoniometer, Zeiss' Stereoplanigraph, Wild's Autograph, and (using anaglyphs as previously demonstrated) Zeiss Multiplex Aero-projector, to mention but a few.

Map-making, however, is not the only use to which aerial photographs can be put. As some one has said, they are the means by which the landscape may be brought into the office, where, with the simplest kind of a stereoscope, it can be

examined in depth and in detail,—a wealth of detail that can only be abbreviated in a map. Thus the photographs themselves may be used for the classification of forests, the location of highways, railways, power sites, transmission lines and irrigation schemes; and they serve as a most useful type of map in the field for foresters and geologists.

In some cases the photographic map or mosaic is more useful than either the line map or the individual photographs. It has the advantage of containing all the detail, and heights may be indicated on it by means of approximate contour lines; but, unless adequate ground control has been used in its compilation, errors may be serious.

It is difficult to convey the subject matter of the lecture in a written abstract without the illustrations that accompanied it. Over a hundred slides were shown, including theoretical diagrams, types of cameras, auxiliary equipment, and aeroplanes, examples of photographs obtained in different types of country, stereoscopic anaglyphs, plotting instruments and machines, and maps and mosaics in various stages of production. Through the courtesy of Zeiss Aerotopograph, Jena, and Hughes Owens Co. of Canada, the audience was provided with viewing filters and printed anaglyphs of Boulder Dam. The author also wishes to acknowledge his indebtedness to Squadron Leader Duncan of the Photographic Section, R.C.A.F., Dr. Boyd of the Topographical Survey, Department of Mines and Resources, and Mr. Jenkins of Canadian Airways, for the illustrations of their equipment, processes and products; to the R.C.A.F. for permission to show their photographs; and to his colleagues in the Department of Applied Physics for their able assistance in the preparation of many of the diagrams and their execution of a complicated projection programme.

"THE ISOLATION OF ISOTOPES"

HAROLD C. UREY

In the present century it was found that many elements which were formerly believed to exist in one form with but one atomic weight did in reality exist in many forms with differing atomic weights. There are, for example, eleven different forms of tin which, as far as we can make out, have the same chemical properties but different atomic weights. We say that tin has eleven isotopes.

In 1931 a hydrogen isotope which had twice the mass of the ordinary hydrogen atom was discovered. The ordinary atom is now referred to as protium, while the heavier atom is called deuterium. About one atom in six thousand of the hydrogen atoms which make up water is a deuterium atom.

In 1933 a 99.9% preparation of deuterium oxide (so-called "heavy water") was obtained by electrolysing 25,000 volumes of water till only one volume remained. Because the mass of the deuterium atom is twice that of the protium atom easily measurable differences between deuterium oxide and protium oxide were observed. The boiling point of deuterium oxide is 1.4 degrees C. below that of protium oxide. This fact enables us to use the fractionating column to separate the two oxides which make up ordinary water.

The fractionating column is used in industry to separate liquids whose boiling points differ—say toluene and benzene. In the present instance the difference in boiling point is so slight that a very efficient instrument thirty-five feet high and six inches in diameter was constructed. At the base of the column water is boiled, the vapour rises to the top where it is condensed and returns to the bottom. Twelve hundred rapidly revolving steel plates force the rising vapour and falling water into intimate contact. A quasi-chemical reaction occurs. Heavy hydrogen atoms in the rising vapour tend to

change places with light hydrogen atoms in the falling water, and vice versa. Gradually heavy hydrogen water concentrates at the base of the tube and is drawn off.

The separation of light and heavy nitrogen (atomic weights: 14 and 15 respectively) was accomplished in 1936 by the use of the fractionating column. The vapour phase is ammonia gas, the liquid phase, a solution of ammonium sulphate. Two-fifths of a pound of 2½% heavy nitrogen ammonium sulphate were obtained per day.

Heavy carbon has been discovered and prepared, albeit in very small quantity. This completes the great triumvirate of elements which play so important a part in animate nature.

The presence and concentration of heavy nitrogen, hydrogen and carbon are determined by the mass spectrometer. Samples of the gas are bombarded with an electron stream and the component atoms electrified or ionized. These charged atoms are then deflected in a magnetic field to determine their relative mass. By this means we can detect so slight a difference as a hundredth of a millionth of an ounce.

Biochemists have used deuterium to investigate hitherto obscure processes of intermediary metabolism. When we eat a piece of fat what happens to it? Where does it go? All fats contain hydrogen, and fat can be synthesized using heavy hydrogen rather than ordinary hydrogen. We can feed this fat to animals and then watch for heavy hydrogen atoms in various parts of the body.

By using these tagged atoms we have learned that fat is not converted directly into energy, but first stored in the fatty tissues, and that it may be stored and removed many times in the course of a few days, so that these tissues are not the inactive tissues they are generally supposed to be. We have shown that if necessary the three kinds of fats within the body can be converted one to the other, and that if no fat is available to replenish the fatty tissues, the body can synthesize fat from protein and carbohydrates.

Protein foods contain nitrogen. It may be possible to use heavy nitrogen tags to follow the course of such foods through the body until they are excreted as urea. To do this we may have to grow plants using specially prepared heavy nitrogen fertilizer so that they will build up an entirely different kind of protein food.

Since hydrogen atoms are the simplest of all the atoms, physicists working with light and heavy hydrogen have been able to study and verify many theories, which in turn enables them to interpret the behaviour of more complex atoms and molecules.

The transmutation of the elements is a scientific development of paramount importance. The neutron is the most powerful transmuting agency we possess. A particle with the weight of an ordinary hydrogen atom, it carries no charge to inhibit its activity. It is obtained most abundantly by bombarding beryllium with deuterium nuclei.

"FOOD PRESERVATION"

W. H. Cook

INTRODUCTION

Food preservation has been a problem since primitive time, and the complexity of our modern civilization has contributed to its importance. The diversity of the modern diet calls for products produced in both tropical and temperate climates in nearly every home, while the great metropolitan areas of the world are dependent on distant agricultural regions for their everyday foodstuffs. These conditions can only be met by the successful transport of perishable commodities over relatively long distances—sometimes half way around the world. Even within a given country or region, certain commodities can only be produced seasonally and they must be preserved over relatively long periods if the consumer is to enjoy them throughout the entire year. Successful transport and storage methods also aid the producer by widening the available market for his commodities and reducing seasonal gluts.

By its very nature, the food industry is the largest and oldest in the world, and many of the methods of preservation preceded the scientific era. Since the middle of the 19th century science has contributed materially to our knowledge of preservation, but many of the methods employed still have their basis in practice and experience, rather than in scientific discovery.

Food is derived from living organisms which at some stage in their life cycles are edible, nutritious and usually palatable. The object of preservation is to retain these attributes over a period comparable with that required to reach the same stage in the next life cycle; in other words, from one crop year to another. Perishable foodstuffs are characterized by a high moisture content, and a number of the lower organisms, usually

non-pathogenic bacteria and moulds, derived from the soil, air or the product itself, also find the particular commodity palatable, edible, and nutritious, and unless they are removed, or some conditions imposed which prevent their growth and development, they soon remove the palatability factor, and the human is then decidedly less interested in its nutritive qualities regardless of its edibility. The methods used for preserving foodstuffs may therefore be classified in accordance with the method employed for suppressing microbial growth.

DRYING AND CURING

Since the relatively non-perishable commodities are characterized by a low moisture content, it is not surprising that drying constituted one of the early methods of preservation. A large variety of plant and animal products, including apples and other fruits, and even milk and eggs, are widely used to-day in the dried form. This method has the advantage of being relatively cheap, the commodity can be stored for quite long periods, is not injured by freezing temperatures, and the bulk and weight of unit quantity of dry material is comparatively small. All of these advantages favour the use of dried materials in outlying districts where transport facilities are limited and a relatively stable material is required. This method has the disadvantage of producing a processed product with less appeal to the palate than the fresh article and the number of uses to which it may be put is frequently restricted.

Curing involves the addition of salt, sugar or other ingredients to the product. The fundamental preservative principle is essentially the same as in drying, the added constituents producing a condition of "physiological" or "osmotic" dryness, which prevents, or retards, the absorption of water and nutrients by the micro-organisms. The mild cures favoured to-day frequently do not accomplish the complete inhibition of the organisms, and the products must still be considered perishable. Curing is also one of the older methods of preser-

vation and it is doubtful whether man made a direct discovery that meat could be preserved by adding salt or whether it was discovered incidentally to the application of salt to partly spoiled meats in order to mask the foreign flavours arising from decomposition.

Curing, like drying, results in a processed product, and although some of the flavours so obtained are desirable, as in bacon, there are many commodities that do not lend themselves to preservation by this method.

CANNING

Unlike drying and curing which merely inhibit the growth of organisms without necessarily destroying any of them, the basic principle of canning is the destruction of these micro-organisms. Canned foods have consequently been defined as sterile foods in a hermetically sealed container. Evidence has been accumulated however, which indicates that such a definition cannot be maintained. Although the pathogenic organisms are destroyed, many satisfactory canned foods contain a few viable micro-organisms, and the term "commercial sterility" might well replace the term sterility, which implies complete destruction of the micro-organisms. The remaining non-pathogenic organisms seldom cause spoilage as they cannot grow or develop. They are usually spore-forming aerobes which cannot grow in the absence of oxygen. Others are inhibited by the acid concentration found in canned fruits, or by the salt concentration used with canned meats.

Canned products are again processed products, are not strictly comparable with fresh products, and have a more limited variety of uses.

REFRIGERATED STORAGE AND TRANSPORT

In refrigerated storage and transport, the basic preservative principle is the reduction of temperature to a point

where the growth of micro-organisms is greatly retarded or prevented entirely. Some of the organisms may perish but no attempt is made to destroy them. Other than cooling, little or no processing is done, and when the product is warmed up, it should enter into direct competition with fresh material. This method of preservation can be used to extend, if necessary, the storage life of nearly all types of fresh or processed products. In view of the growing importance of refrigeration in the preservation of foodstuffs, the remainder of the time will be devoted to a discussion of this subject.

The value of reduced temperatures for preserving perishables has been known from antiquity, but its general application in commerce had to await the development of mechanical refrigeration to render the required conditions independent of season and climate. These engineering developments took place during the 19th century, and by the year 1900 mechanical refrigeration had been applied quite generally to the storage and at least to the ocean transport of perishables.

Superficially it would appear that the provision of the required cooling equipment was the complete solution of the problem. All that appears necessary is to determine the temperature below which no organism can grow or develop, and then provide a slightly lower temperature for storage. Unfortunately it is not as simple as this.

In the first place, certain organisms can grow or develop at temperatures below the freezing point of most products. Since certain commodities cannot be frozen without suffering at least physical deterioration, these must be stored at temperatures above their freezing point, and consequently are still subject to deterioration by micro-organisms, although their growth and development are repressed by the reduced temperatures. Secondly, some products such as fruits are stored in the living state and their life processes, and eating quality, are seriously affected if they are stored at temperatures only slightly above their freezing points. Certain products liable to these functional disorders must be stored at temperatures

as high as 55°F. and are consequently subject to relatively rapid deterioration by micro-organisms. On the other hand, if the product can be frozen, temperatures below 20°F. are required to inhibit microbial development completely. Even temperatures just below 20°F. may not be entirely satisfactory, for although microbial growth may be suppressed the product can still deteriorate from enzymic, chemical and physical changes. The inhibition of these changes in certain products, for the required storage period, by the control of temperature only, sometimes involves the use of the lowest temperatures economically feasible. At the present time this is about −20°F. Temperatures below the freezing point are commonly referred to as "frozen storage" and higher temperatures as "chilled" or "cool storage".

Products that can be frozen may be stored several times as long as the same commodity held in the chilled state. Nevertheless the majority of products must be stored above the freezing point since freezing causes physical deterioration, followed by more complex changes when the material is thawed. During recent years considerable development has taken place in the methods of freezing with the object of preventing this physical deterioration. Quick-freezing aims at freezing the product in an hour or two, instead of the 10 to 72 hours ordinarily required. The advantage claimed for this method of freezing is that the ice crystals, formed within the product, are smaller and cause less mechanical disruption of the cells, and less severe physico-chemical changes take place. This method of freezing appears to be superior for certain products, although it does not appear to confer any advantage in others. In any event low storage temperatures are necessary for storage subsequent to quick-freezing to prevent growth of the initially small ice crystals.

Another method for extending the storage life of products that cannot be frozen is by using some supplementary method of preservation in addition to reduced temperatures. The most successful of these has been the introduction of certain

non-toxic gases into the atmosphere of the store. Ozone, or tri-atomic oxygen, produced by a silent electrical discharge through air has been used for a number of years. This material is claimed to reduce the growth of micro-organisms and destroy foreign odours. It seems probable that it does assist in maintaining the quality of the product, but its value is difficult to assess. It may also extend the storage life to some extent. Another gas that is frequently used in the storage atmosphere is carbon dioxide in a concentration of about 10%. The maintenance of these concentrations requires a gas-tight, as well as a refrigerated, room. Nevertheless this extra expense is justified by the fact that the respiration rate of apples is reduced to about half of that occurring at ordinary temperatures, and the storage life roughly doubled in consequence. Similar concentrations almost double the storage life of chilled beef by depressing the growth rate of the micro-organisms. This method of "gas-storage" has been applied commercially to the storage of apples in Great Britain and to the transport of chilled beef from Australia to England.

In the successful storage of any product under refrigerated conditions, the relative humidity of the atmosphere plays an important role in determining the storage life. Most products suffer a shrinkage by evaporation during storage if the relative humidity of the atmosphere is less than about 95%. The atmosphere in most storage spaces is less than this owing to the presence of the cold cooling surfaces which condense the moisture from the air. At chill temperature, relative humidities somewhat lower than 95% are generally recommended, since microbial growth increases as the relative humidity is increased. It is therefore necessary to use an atmospheric humidity in which the particular commodity will not suffer accelerated deterioration by micro-organisms on the one hand, and excessive shrinkage on the other. The best humidity naturally varies with the particular product, but for many of them it is in the vicinity of 85%. At the temperatures used for frozen storage, microbial growth is not a serious considera-

tion, and shrinkage is the only factor to be considered. Humidities in the vicinity of saturation are recommended under these conditions, but are difficult to attain owing to condensation on the coils in the form of frost, making efficient cooling impossible.

FOOD INVESTIGATIONS IN CANADA

Investigations into the refrigerated storage and transport of perishables are usually limited to a comparatively small number of institutions because of the elaborate and costly equipment required. Few of the Canadian universities are equipped to undertake systematic investigations in this field. The Ontario Agricultural College at Guelph is an exception. Most of the investigations under way in Canada are supported by various Departments of the Federal Government. The most important of these are the Fisheries Research Stations at Prince Rupert and Halifax, the Central Experimental Farm at Ottawa and a few of its branch farms, and the National Research Laboratories. The Fisheries Research Stations are engaged in studying the preservation of fish, and engineering problems relative to its transport and storage. The Experimental Farms investigate the storage of horticultural products, principally apples. When the National Research Laboratories came into existence a few years ago, there were numerous requests to have certain problems investigated relative to the transport and storage of meat products, and the engineering phases of storage. Since that time we have studied: the storage conditions provided for celery in commercial warehouses; the heating of insulated railway cars in winter to prevent freezing; the chilled and frozen storage of poultry; the quick-freezing of meats; the humidification of freezers; and we are now initiating extensive studies on the manufacture, storage and transport of bacon.

I hesitate to discuss the education of suitable technologists for the food industry. There is always the feeling that the introduction of courses covering these practical phases of

industry into a university curriculum would result in the degeneration of the university into a technical school. On the other hand there is a decided need for suitably trained food technologists. The successful storage or transport of each individual product awaits the solution of some fundamental problem requiring the best efforts of a well-trained investigator. Practical technologists are also required to apply these findings in industry. Food preservation has advanced a great deal since the World War but it has still a long way to go before every product can be kept in prime condition for the required length of time.

Proper methods of food preservation are of interest to the entire world population, whether the individual be a producer and consumer, or a consumer only. The solution of certain of these problems is of particular interest to Canadians. Since we produce many commodities seasonally, we face relatively long storage periods for our domestic trade, and since our seasons of production correspond closely to those in Great Britain, our greatest consumer, storage is again important from the export angle. We have problems in marine transport but these are not as serious as for countries such as Argentina and Australia who are several times as far from Great Britain as we are. We have, however, serious problems in rail transit and are limited in warehousing facilities and equipment for transferring goods from one kind of carrier to another, i.e., from train to ship.

In the past these problems have been solved by men trained in diverse fields and whose knowledge of the cold storage industry has been gained from experience and practice. Experience is essential but the situation would be much better if the men entering industry had some knowledge of biological principles as well as those of physics and chemistry. This does not necessarily mean the introduction of new courses into the already overcrowded undergraduate curriculum. It does mean that a few students should be allowed to take a few less courses in the physical sciences and a little more biology.

The organization, however, must be such that they can get the essentials of the several sciences in the right proportion.

Following graduation specialized courses and research might be undertaken on problems relating to the food industry in accordance with the inclinations and abilities of the individual student. It would appear that some of the fundamental problems such as the measurement of humidity and the properties of refrigerants, in other words the properties of matter in mass, should be just as interesting as bursting the atom. Many of the substances responsible for the flavour of food offer a challenge to the chemist interested in micro-analysis and structure. Some of these substances occur in such small proportions that the present micro methods are too crude to detect them, much less to determine them quantitatively. Yet the presence of these substances distinguishes a palatable food from a substance providing nutrition and exercise for the jaws. The animal physiologist could well extend his field to a study of the changes that occur in muscle after rigor, in addition to those of the living animal. The field of bacteriology has been dominated largely by medical pathology and the budding bacteriologist may well be interested in the fact that a great many bacteria are not pathogenic, that they prefer to grow at 20°C. instead of 37°C. and that in fact they will grow and develop at temperatures considerably below the freezing point.

From the Canadian standpoint the importance of investigations into the storage and transport of perishable foodstuffs needs hardly to be stressed. Our wheat market is no longer as secure as it once was, and the alternative in an agricultural country such as ours is perishable foodstuffs. Such products can be expected to find a ready market in Great Britain who imports roughly 50% of her beef and mutton, 65% of her pig products, 80% of her cheese, 90% of her butter and 75% of her apples, to cite only a few examples. Certain of these commodities can be produced more economically in other countries, but with some products the advantage is in our

favour. We can reasonably expect to supply a greater proportion of the requirements of the British market. Of the perishables which we now export, bacon heads the list in terms of value, but Denmark still supplies the bulk of the bacon imported by England. Similarly Argentina supplies the bulk of Britain's imported beef.

Canada can produce many first-class foodstuffs. The British market demands high quality on delivery, and our initial quality means nothing if the storage and transport link is weak. We must do our utmost to improve this link through knowledge and facilities, so that we can compete successfully with other nations who are more favourably situated geographically.

"SCIENTIFIC CRIME DETECTION"

L. Joslyn Rogers

In the strict sense of the term, scientific crime investigation is a misnomer. The scientific method implies a broad attack upon a problem, and the background for scientific criminal investigation has not yet been developed.

The laboratory technician is to-day concerned with linking the suspect to the time and place where the crime was committed. As a rule he does not visit the scene of the crime to obtain evidence. An integral part of this system is therefore an alert, intelligent police force, adept in selecting evidence the technician can use.

Gradually, however, the scientific approach is being developed. We now realize that crime diverts an enormous amount of money from legitimate business channels, a concept fostered by sensational exposures in the United States.

Arson, for example, is a crime very tempting to a certain class of people. During the 1929 depression and the 1938 recession it was particularly serious, but the chemist fought it with considerable success. Yet if arson were eliminated, our domestic insurance rates would be reduced fully a third.

As new threats to our security arise, the scientific criminal investigator moves to meet them. During O.T.A. days, the consumption of alcohol was the direct cause of many deaths. Seventy-five per cent of these were attributed to illicit swamp whiskey, 15 per cent to denatured alcohol, and 10 per cent to legally manufactured whiskey smuggled into the province.

To-day many people are wantonly slaughtered on the public highways by those who drive motor cars while under the influence of liquor. Yet until recently scientific proof of the consumption of liquor entailed analysis of the stomach content, and unless the suspect had been drinking within the past hour, the finding would be blank.

A more ready and accurate method, based on ascertaining the proportion of alcohol in the blood of the suspect, has been developed and applied in England and the Continent, and is now being introduced in this country. A man with more than $1\frac{1}{2}$ parts of alcohol per 1000 in his blood is definitely under the influence of liquor, and a man in that condition should never drive any speedy vehicle.

At the present time the written consent of the suspect must be obtained before this blood test can be applied. We may shortly expect legislation to rectify this.

Dr. Rogers concluded: "While the stories I have recounted this evening might be considered in lighter vein, I assure you there is never a case that has not a tragedy written across it in very deep letters. However, I should like to tell you one more story of considerable psychological interest.

"Some years ago, in late November, two people were found dead in a summer cottage adjacent to another country. The wife of a man who lived in the other country was found dead in the house; the husband of a Canadian woman was likewise found dead. The couple had apparently kept that rendezvous more than once.

"They were missing two weeks before they were found. When the police arrived they observed that a meal had been partaken and the remains left on the table. There was no indication that anything in the food had caused their death. It was thought that when they sat down at the table they died, yet that they died in such a way that both came to their end simultaneously, and that neither knew what had happened.

"I was given the viscera of those two people and all the food in the house, yet though I hunted diligently for two weeks my findings were quite blank. Even so, I, a school-teacher, felt quite confident I knew how those people died. I believe that a little applied psychology would have unearthed some one who could have thrown some light on the subject.

"Remember, they died simultaneously. That means a

good deal to a chemist. It means that one of a very few of a number of things could have been used to bring about such a condition.

"Likewise, I think one could fairly well determine the responsibility for the death of those people. When a man has cause to slay for the provocation that might have been here, he never seems satisfied unless he messes things up pretty well. He has that nasty habit or characteristic.

"But women are not like that at all. Women are gentler in their means. Women are poisoners. Women are different in their natures. No matter how evil a man has been during his life, she always pictures him a handsome corpse. She thinks she has chosen one of the handsomest men in creation for her mate. That is part of a woman's vanity. And there isn't anything in the incident I have described that has the appearance of the act of a man at all.

"There is another thing that suggests there was a woman behind it that knew all about it, and that it was a woman who engineered it. She didn't worry when they sat down and ate, but she did want to show the world why those people died. Now a mere male might say that it didn't make any difference. But a woman is right and never wrong, and that woman was right, and she didn't make any mistake. She showed the world the conditions under which this man and this woman died.

"Those are the reasons why I think a little psychology would have solved that case. I tell that story as one that would make the basis for an interesting yarn; I think it is a really striking one. If any authors in the audience care to use it, I should be very much interested in how you work out your solution.

"At this juncture I find I have talked longer than I intended; but that again is a school-teacher's privilege."

"MUSICAL SOUNDS AND THEIR ENGINEERING"

WILLIAM BRAID WHITE

Musical sound, old as the pipes of Pan, has received detailed scientific study only since the advent of radio. Dr. White's lecture, based on research undertaken at the acoustic laboratories of the American Steel and Wire Company in Chicago, the world's largest manufacturer of wires for musical instruments, dealt with the physics of sound.

Sound (musical or otherwise) results when airwaves emanating from a vibrating body impinge upon our eardrums. Under favourable conditions the human ear can detect vibrations between the limits of 20 to 25,000 cycles per second; the range of the pianoforte (27½ to approximately 4,200 cycles per second), however, encompasses the practicable range of musical sound.

The central secret of musical sound lies in that property called "colour" or "quality", whereby the voice of one instrument is distinguished from that of another, and one spoken or sung sound coming from one person distinguished from the same sound given out by another person. A musical instrument may produce different tone colours; the G string of the violin emits a warm, rich tone, the very antithesis of the clear, brilliant tone produced by the steel E string in common use to-day. To a certain extent, too, the artist's approach to his instrument will determine tone colour; the works of a strict classicist such as Bach are, on the whole, treated differently from the compositions of a romanticist such as Schumann.

The pitch of a vibrating string is inversely proportionate to its length. Dr. White showed that a string set in motion either by percussion, plucking or stroking vibrates not only as a whole, but also divides and vibrates in two, three, four and more segments. Every single tone, therefore, produced by a vibrating string is a complicated tone, consisting of the fundamental tone upon which accessory tones are built. The

key to the mystery of musical sound is to be found in the scientific study of these harmonics, for they give the tone its timbre. Particular harmonics or sets of harmonics, unduly stressed or interfered with, affect the quality of the tone for better or for worse. Two violins, superficially alike, may differ considerably in tone colour because of minute differences in their construction. One may stress (say) the sixth, seventh and eighth harmonics; the other, the second, fourth, sixth and eighth: The tone of the second will be more mellow than that of the first, because its harmonics give more body to the fundamental.

The use of the projection oscilloscope makes it possible to show much of the hitherto unknown influence of the musician's personality upon the instrument he plays, or upon his manner of singing and the results he gets. With this instrument, musical or other sounds given out in any manner are picked up, transformed into electric energy, and caused to vibrate a tiny mirror set in a magnetic field. A beam of light is thrown upon the fluttering mirror, which dances in accord with the rhythms and speeds of the sound waves, and the resulting dot of light, reflected against a revolving wheel of mirrors, is thrown upon a screen as a line of moving light, breaking up each instant into new forms of remarkable symmetry and beauty, as the sounds succeed each other. Noises, on the contrary, show their shapeless and incoherent nature in the broken and ugly forms which they display upon the screen. The oscilloscope brings the eye to the aid of the ear and shows the subtle and beautiful differences and variations of musical sound with a distinctness otherwise impossible to achieve.

This is the age of radio. Never before in all history have millions of men and women become definitely interested in musical art; the broadcasting arts and sound engineering are exerting powerful influences upon the practice of the art of music and upon the reaction of the masses of the public thereto. Dr. White believes that the people of this scientific age have an intense and urgent need for an art which, in the words of Beethoven, "begins where words end".

"THE SOCIAL EXPERIMENTS IN DENMARK AND SWEDEN"

DENTON MASSEY

In the midst of changing societies and systems of government, Denmark and Sweden have remained steady on an even keel. They have made tremendous strides in solving their problems in the midst of a world beset by rapidly changing economies. Sweden is primarily industrial; Denmark, agrarian.

It is on the twin foundation of practical religion and practical cultural education that modern Sweden has been built. Throughout the years of her history Sweden has clung fast to her church: it is cradled in the state; it is the prime duty of the state to forward and preserve that church. The Swede practically applies his simple religion—Lutheran.

The curriculum of Swedish schools is intensely practical and up-to-date. Religion, music and musical appreciation, and gymnastics find a place on this curriculum. Every boy is taught a trade of some kind, irrespective of who he is or who he thinks he is, so that when he leaves school he has already served part of his apprenticeship. The girls are taught household economy. No child who is worthy of taking advanced study is denied that study because of inability to pay. For those who have left school there are folk-schools where men and women of mature years may acquire knowledge.

Throughout her development the individual has been of prime importance. It is on the individual that all national activity is focussed. The result is that the individual develops into a fine citizen, possessed of a pride which is an intense inspirational force, tolerant and generous in its application of that tolerance.

Their sense of individual dependency one upon the other

is refreshing. There is good fellowship between employer and employee. Trade unions are stronger in Sweden than in any other country in the world, yet strikes are rare. Mediation and compromise is everywhere evident.

Laws and statutes are few in Sweden. They govern themselves by common sense and a respect for the other fellow. If the state were not founded on such principles it would be impossible to explain the extraordinary changes that have taken place in the activities of the country without untoward disturbances. In 1850 only 10% of the population lived in towns; 85 years later 55% of the population were living in towns. Yet there are no slums and no unemployment. Throughout the country there is apparent a sense of social security.

No phase of Swedish life has attracted more attention than their co-operatives. Co-operatives alone do not seem capable of solving a nation's basic economic problems; they must be supplemented by political action. Swedish co-operatives are excellent examples of this.

To-day one of the co-operatives—Kooperativa Forbundet (commonly called K.F.), does 11% of the total retail trade of Sweden and 17% of the total retail food trade. This co-operative was founded on the original Rochdale motif: open membership; democratic control; all business on a cash basis; all goods to be sold in private competition; limited return on the capital invested; distribution of all profits after deduction for education and expansion.

Sweden is well supplied with forests. They are so carefully conserved and reforested that there is to-day 40% more timber available than in 1850.

The urbanization of Sweden already referred to brought about a housing problem. It is to the everlasting credit of Sweden that they were aware of this movement from the beginning and never let the situation get out of hand. There are four housing plans and the tenant selects the one best suited to his needs. One plan, for example, is designed for

the Swede with a large family. If he has three children (say) he has a thirty per cent reduction in rent; if he has four, a forty per cent reduction, and so on.

. . . . .

The area of Denmark is just over 17,000 square miles, its population, 3,700,000. Twenty-three per cent of the people live in the city of Copenhagen alone; 39% in small towns; and 38% in the country. The Danes are a people of a deep moral sense and their honesty is outstanding.

The most interesting of all their schools are the folk-schools. The older people attend and their studies give them a breadth of vision that is remarkable. A fine description of these folk-schools is found in Agnes Rothery's splendid book: "Denmark: Kingdom of Reason".

Denmark has a state-subsidized scheme for placing families back on the land. At present any man who has two hundred dollars can obtain a fine farm, livestock, house, barn and equipment.

Denmark is primarily an agrarian country; 60% of her exports are agricultural. She competes successfully on the markets of the world because of the exceedingly high quality of her products, which is governed by a rigid inspection system. The Dane develops his product to fit the market to which he is selling and takes full regard of the consumer's acceptance of that product. The Danish policy is a most outstanding example of the ability to produce what is actually required rather than an endeavour to sell a product which the producer himself believes to be inadequate. On this the people base their success of the marketing of their farm products.

The Danish farmer has many co-operatives to help him in the marketing of his products. These co-operatives transact all business in his behalf and leave him free to attend to his duties.

"THE CELL AS THE ARCHITECTURAL UNIT OF THE BODY"

ROBERT CHAMBERS

In the words of Francis Bacon, essayist, jurist and philosopher,—"We must not eschew experimentation because it is a search for light and not for fruit." This observation, said Dr. Chambers, is amply substantiated by the experiences of the microscopists of the eighteenth and early nineteenth centuries. Berated by their contemporaries as visionaries pure and simple, in the latter half of the nineteenth century their researches flowered into the intensely practical work of Pasteur, Koch, and other microbe hunters—a denouement Dr. Chambers commended to the attention of those who deprecate the time, talent, money and effort spent in the interests of "pure" science.

In 1839 investigators realized for the first time that the cell was the real unit of structure and function; and a new era in cellular biology was inaugurated. It was established that all cells rise from previous cells—spontaneous generation is a spent theory; and that there is a tremendous variety of highly-specialized cell types—indeed, cytology has almost come to mean the study of cell morphology. By staining cells with suitable dyes, much can be learnt of their structure; it is extremely difficult, however, to delve into the constitution of the cell as a biochemical unit. This latter phase has been much neglected, since scientific research, in common with every other line of endeavour, tends to follow the path of least resistance.

This condition must be remedied. Medical science is demanding a more detailed knowledge of cell physiology. Chemists have constructed artificial protein molecules that are all but living; it behooves the cellular biologist to investigate the structure of the house in which these protein mole-

cules function. The atomic physicist was at one period a mechanist; to-day, with accumulated data at his disposal, he has turned to the mathematical analysis of phenomena. By that standard, the cellular biologist is a primitive mechanist; he must find out if the cell is a blob of jelly or a bit of liquid surrounded by a wall; if that wall is solid; how various parts of the cell react to simple chemical agents; what part of the structure of the cell is necessary to maintain the cell in a living condition. These are manifestly simple things, but he must settle on these simple things before he can proceed. He has devised a means—the micro-manipulator.

The micromanipulative technique depends upon a mechanical contrivance to manipulate microneedles and pipettes in the field of the compound microscope. The tips of the needles and pipettes, which are generally made of glass, are as fine as can be devised and the adjustments of the mechanism holding them are exceedingly accurate. For example, the tips of two needles can be inserted into a living cell having a diameter of only seven to eight microns and, by moving the needles apart, the cell can be stretched without destroying it. However, successful injection of a fluid into such a small cell is a matter of chance. With the present development of the technique, micro-injections which are sufficiently reproducible for a serious study—e.g., the effects of chemical reagents on the interior of living cells—must be done on much larger cells. Examples of these are the fresh-water ameba and marine eggs of the sea urchin and starfish. These cells on the average have a diameter of about 0.007 cm. or 70 microns.

The value of the micromanipulation technique for studying the poperties of protoplasm becomes evident when one realizes that protoplasm exists as such only when it is confined within microscopic dimensions and is bounded by its peculiar membrane. It is this membrane which determines the property of selective permeability of the living cell. Protoplasm—the semifluid, semitransparent, colourless substance consisting of oxygen, carbon, hydrogen, and nitrogen, the basis of life in

plants and animals—is so unique a chemical entity that investigators believe it must have been formed at some remote period in the earth's history when environmental conditions were especially propitious.

The actual existence of this membrane as a definitely differentiated structure has been regarded hitherto as hypothetical. It can be demonstrated by the micromanipulation method in various ways. A striking one is the micro-injection into a living cell of the solution of a nontoxic dyestuff to which the cell is normally impermeable. The colour of the injected solution quickly diffuses through the interior of the cell and stops on reaching the cell boundary. Evidently the interior of the cell is freely permeable to the dye and the inability of the dye to get in from without the cell or to pass out from within must be ascribed to a surface layer which is impermeable to the dye from either side.

Cells demand a specific, salty, aqueous environment, which seems to suggest that the first cells had their being and functioned in the ancient seas. In the human body, the environment—i.e., the blood plasma—is maintained in its proper balance by the action of the kidneys, which excrete the superfluous salts. Calcium salts are necessary to stiffen and coagulate the extraneous coatings of cells; if they are absent the organs collapse in a flabby state.

Experiments to ascertain the surface tension of the naked surface of the protoplasmic cell give a value far below one dyne per square centimeter; small wonder, therefore, that cells exist only in minute dimensions since they could not grow much larger without becoming very instable.

The protoplasm of a living cell is able to repair a torn surface if the tear is not too extensive, and if the environment is normal. This is well illustrated in microdissection experiments on starfish eggs in sea water. No breakdown occurs if the tip of the needle is moved slowly through the protoplasm and out of its surface; but if the piercing action is performed suddenly, the surface film disrupts and the exposed cytoplasm

will begin to spread out and its granules to scatter in the medium. While this is occurring, films may appear around the masses of the disorganizing material which swell and burst. Frequently, films form beneath the disorganizing region within what is still normal cytoplasm. These films may unite and reach the intact, original plasma-membrane which surrounds the healthy portion of the protoplasm of the egg. After this no further disintegration occurs and the protoplasm, with its intact membrane, rounds up to constitute a diminutive but viable egg.

The internal protoplasm is endowed with the ability to buffer itself against excess acidity or alkalinity—a very important attribute, since cells breathe, i.e., take in oxygen and expel carbon dioxide, and an excess of carbonic acid would create a degree of acidity sufficient to coagulate some of the proteins in the protoplasm.

The lecturer then screened a remarkable film showing leucocytes (white blood corpuscles) leaving the blood stream to penetrate living tissue; invading a micro test tube by their attraction to the sugar solution in it; and, finally, attacking and destroying a colony of bacteria. It was a most impressive finale, the more so as it depicted phenomena biochemists are unable to fathom with the present knowledge at their disposal.

"GROWTH—INNOCENT AND MALIGNANT"

WILLIAM BOYD

Growth is an attribute of all living things, its limits more or less fixed by heredity. The organs of the body grow to their allotted size not by cellular expansion, but by repeated cellular division.

Of the numerous and complex factors governing growth, food and vitamins are of especial importance. Vitamin D deficiency, for example, induces rickets; and a child with untreated rickets may become a dwarf.

The hormones of certain of the ductless glands are necessary for proper growth. The hormone of the thyroid gland is essential for the development of both body and mind; while undue activity of the pituitary may provoke a giant, and under-activity, a dwarf.

To medical science, cessation of growth is as important as its continuance. Normal cells know when to stop, yet certain tissues that have long since ceased to grow have not lost their power of growth, for the fibrous or connective tissues which lie under the skin will proliferate to heal wounds in the body. The cells of the nervous system, however, have lost this ability; once destroyed, as in infantile paralysis, they cannot be replaced.

Why certain tissues should retain the ability to proliferate until they have satisfied the needs of the body we do not know. It seems likely, however, that as a result of injuries some growth-promoting substance is liberated which stimulates the neighbouring cells to multiply until the injury is repaired.

We do know that differentiation inhibits growth. In the early stages of development all the body cells are similar; as development proceeds they gradually take on the appearance of the cells of the special organs they are going to make up

later. When cells become completely differentiated (or specialized) growth comes to an end.

Embryonic cells transferred to a suitable medium continue to grow forever; but immortality cannot be attained by adult cells on which the fingerprints of age and the sharp tooth of time have already left their mark. Malignant and cancerous tumours can also be grown in vitro, which greatly facilitates research.

The most sinister manifestation of abnormal growth is cancer. Not an infectious disease introduced into the body from without, it is an outlaw group of body cells which insist on proliferating in frank defiance of their environment, probably through the breakdown of growth-restraining elements with which the body cells are normally endowed.

Tumours are either innocent or malignant. The former are formed of cells piled on the surface of the skin by the pressure of underlying tissues; the latter, of outlaw cells which spread downward, infiltrating the adjacent tissues. Every last vestige of a malignant tumour must be removed; otherwise the remaining cells will proliferate and the tumour recur. Cancer cells also invade the lymphatics and the blood vessels, in this way spreading to many parts of the body. The radiologist or surgeon is powerless to cope with cancer in this rather advanced stage. Theoretically all cancer is curable in its early stages; but many deep-seated cancers cannot be diagnosed until they are beyond control.

Cancer research has advanced mightily in recent years. It is thought that two factors are needed to induce cancer—the intrinsic and the extrinsic. Three extrinsic factors have been found.

1. In 1915, a Japanese worker found that tar applied to the skin of a rabbit over a number of months would induce a cancer. This is the greatest single discovery in the history of cancer research. Paraffin oil and x-rays are similar cancerogenic agents. Such agents may be irritative; we do know

that an ill-fitting plate or jagged tooth may, over a period of years, cause cancer of the mouth.

2. Cancer of the breast develops in mice subjected to repeated injections of the ovarian hormone which incites the female breast to develop at puberty. The close chemical affinity between this hormone and cancerogenic agents obtained from coal tar suggest that the solution to the cancer problem may be a matter of chemistry.

3. It has long been known that cancerous tumours may be transplanted from (say) one mouse to another. It is now known that in the case of a few tumours it is possible to filter off all the tumour cells from a fluid suspension, and yet to produce cancer by injecting the clear fluid which passes through the filter. It would appear that this fluid contains a filterable virus which is cancerogenic.

The intrinsic factor which predisposes the body to cancer is linked with heredity. It is possible to breed a strain of mice either very resistant or very susceptible to (say) cancer of the breast. In a Mendelian sense, predisposition to cancer is a recessive characteristic, to be bred out by repeated cross-marriage.

The public must realize that cancer in its early stages is curable by X-rays or the knife. "Secret cancer cures" may remove the external manifestations by caustic action, but they permit the cancer to pursue its nefarious way beneath the surface and secure a hold which cannot be broken later by orthodox treatment.

Professor Boyd concluded: "We have travelled a long way from the point from which we started. In the course of that journey we have seen that animals grow in size not by virtue of the cells—the building stones—getting larger, but because they keep on multiplying and dividing. This power of multiplying at first appearance seems unlimited; but differentiation and specialization (or the force of environment) makes itself felt and growth becomes increasingly inhibited. This influence man overcomes by removing the cells from the body and

allowing them to grow in a culture, and they put on immortality. Cancer cells have freed themselves from their environment and have learned the secret of perpetual youth. We have observed that fact in connection with experimental cancer, the true significance of which is still dim to our eyes. We have seen that today cancer is not incurable—that great advances have been made along the road, but the way is still dark. But some day, perhaps soon, the light will shine; the rough places will be made smooth. It may seem to you that considering the enormous amount of time and money which has been expended on the problem we have little to show, but slowly, surely, the frontier of knowledge is being pushed back"—

Say not the struggle naught availeth,
The labour and the wounds are vain,
The enemy faints not nor faileth,
And as things have been, they remain;
For while the tired waves vainly breaking
Seem here no painful inch to gain,
Far back, through creeks and inlets making,
Comes silent, flooding in, the main.

"CHEMISTRY AND YOUR AUTOMOBILE"

HUGH S. TAYLOR

Dr. Taylor commented upon the increase in the life of automobile tires due to the use of inhibitors. Retardation of the deterioration of rubber has resulted in a saving of billions of dollars. Duco finishes were also a boon to the automobile producers, replacing the former tedious procedure of 14 coats of varnish, applied over a period of three weeks, by a quick method suitable for mass production. The vogue for light coloured leathers in motor cars has caused the manufacturers much worry inasmuch as the life of these artificial leathers was from four to six months. It was found that the nature of the pigment was a factor in their lasting qualities. Observation that leather quality varied with different pigments led to the development of a non-catalytic series of colours which were entirely satisfactory.

There are few more romantic stories than the development of ethyl fluid by Midgley. Differences of fuel in other respects than calorific value had been observed for some time. The speaker related two instances: the superior performance of Pacific Coast fuel over Mid-Continent oils, and the value to the German Air Force during the latter part of the Great War of Rumanian gasoline as compared with the Pennsylvanian gasoline used by the Allies. Anti-knock gasolines had given an impetus to engine design by allowing the use of higher compression ratios. In America, this increased efficiency had resulted, not in the more economical use of small cars, but in the production of larger and speedier models.

Civil and military aviation supremacy among nations was responsible for the rapid progress in the production of superior fuels. Germany to-day was operating on wartime basis with regard to gasoline production. Forty-five per cent of her petroleum requirements was being made synthetically by the

high-pressure hydrogenation of coke, 5% to 10% by the conversion of coal to water-gas, which with carbon-monoxide was then converted into fuel by catalytic processes. Furthermore, the hydrogenation of coke produced a good fuel, whereas the Fischer process did not. Catalyst manufacture was centralized and local requirements were distributed according to need. Dr. Taylor then described the production or "reforming" of gasoline of 120 octane rating from straight chain C_8 compounds of 40 octane value. It was suggested that though pure iso octylene of 120 rating, from iso butylene and butene, was feasible, it was not as efficiently used in air-cooled motors as in the water-cooled type, and that therefore in Great Britain, for example, the somewhat less ideal fuel was likely to remain in case of restricted engine production in a national crisis. However, in the U.S.A., it was now possible to produce 10 million barrels of 90 octane fuel annually thus leaving no doubt for future requirements of high-grade fuels, with the result that motor and air transportation would possibly be revolutionized.

"PLANT HUNTING IN SOUTH AFRICA"

LIONEL E. TAYLOR

Early in January, 1935, Mr. Taylor and his associates left Victoria, B.C., motored to New Orleans in their "house-car", put the car on board ship and debarked at Capetown. They spent fourteen months in South Africa, travelled 17,000 miles, and visited the Namaqualand Desert.

The primary object of the expedition, and it was the first expedition ever organized for the purpose, was to photograph flowers in their natural colours. Growers in California who cultivated South African plants were anxious to see the exact colouring of the native flowers, as many of these plants grown on this continent are hybrids.

Collections consisted of over 15,000 live plants and bulbs, 8,000 sheets of herbarium material, and 1,500 photographs, 800 of which were taken in colour by the Finlay natural colour process—that used by the National Geographic magazine.

Mr. Taylor described the beautiful gardens bordering Capetown, 1,000 acres in extent, ranging from sea level to 4,000 feet at the top of Table Mountain, and devoted entirely to the growing of South African plants. Here one may see in one place what would take many months of travel otherwise. He deplored the fact that Canada has no National Botanic Garden.

In these gardens grow magnificent European oaks, planted by stolid Dutch burghers in the year 1665, at the behest of their Governor. There too grow the famous Silver Trees, which will grow nowhere else in South Africa, not even a mile away, though there are some magnificent specimens in California.

In French Hook Valley, settled about the year 1700 by French Huguenots, many fine citrus plants are grown, and peaches, plus, pears and grapes abound.

Among the flowers pictured was a species of Amaryllis; the Scarboro lily; one of the 500 known species of South African heath flower; and the white everlasting. Then there are the Moreas, which flower in winter, surviving with 15 degrees of frost. He described a species of Stapelia known as the "Beefsteak Flower"—a very beautiful plant with a most execrable odour. There are some fifty other species of Stapelia, some of which are just as beautiful and far more companionable.

He was very much impressed by the Kruger National Park, a game preserve of 80,000 square miles, left absolutely natural, where many beasts can be seen in their native habitat. While there the expedition was fortunate enough to take one of the two known photographs of a giraffe in the act of drinking.

In the Namaqualand Desert, a little known region in the south west tip of South Africa, he talked to half-bred Hottentots who had not seen rain in nine years. The most curious plant he saw there was the elephant plant. The largest are seven feet tall and, it is estimated, are 2,000 years old. They have no branches, practically no roots, their stems slope towards the north, and the only foliage is a small bunch of leaves at the very top of the trunk.

He saw too the Baobab tree—said to be the oldest plants in the world—the largest of which are from 100 to 126 feet in circumference at the trunk.

Mr. Taylor showed pictures of the Old Dutch Houses in Cape Colony, built during the seventeenth century with teak brought from Java. They are one story in height, thatched with reed, and have typical gable ends. The doors are cut in half like the doors of a barn, and when the upper half is left open the swallows fly in and nest in the beams of the living room. They are encouraged to do so because they rid the place of flies.

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CONTENTS

"Science and Civilization"

ARTHUR R. CLUTE, K.C.
President of the Royal Canadian Institute

October 29th, 1938

In his inaugural address the President emphasized the transcendent debt owed by the modern world to science and the scientific habit of mind traceable to and engendered by the spirit of doubt and skepticism necessarily provocative of enquiry and investigation, which has, in some measure, rescued mankind from the abysmal depths of superstition, ignorance and bigotry and the various forms of persecution so prevalent throughout Europe during not only the benighted middle ages but in times more recent. The attention of the audience was directed especially to the classical work of Henry Thomas Buckle, viz., to his "Introduction to the History of Civilization", first published in 1857. Buckle's thesis that the advance of European civilization is characterised by a diminishing influence of physical laws and an increasing influence of mental laws, which generalization is demonstrable only from history, is based on two premises, neither of which admits of much dispute:

1. That we are are in possession of no evidence that the powers of nature have ever been permanently increased; and that we have no reason to expect any such increase can take place;

2. That we have abundant evidence that the resources of the human mind have become more powerful and better able to grapple with the difficulties of the external world.

We must therefore conclude that the measure of civilization is the triumph of mind over external agents, and that of the two classes of laws which regulate the progress of mankind, the mental class is more important than the physical.

Mental laws are either moral or intellectual. To be willing to perform your duty is the moral part; to know how to perform it, the intellectual part. The more harmoniously they work, the more securely we lay a foundation for the further advancement of mankind. But the question arises, which of these two elements of mental progress, viz., moral feelings or intellectual knowledge, is the more important? Buckle concludes that of the two, moral motives are less strong than the intellectual. The great dogmas of which moral systems are composed are few: do good to others, restrain your passions, honour your parents, respect those set over you, etc. They have been known for thousands of years, and not one jot or tittle has been added to them by all the sermons, homilies and text books which moralists and theologians have been able to produce.

Moral truths are stationary: intellectual truths, progressive. All the great moral systems have been fundamentally the same; all the great intellectual systems, fundamentally different. The moderns have revolutionized the old methods of inquiry, and have created sciences undreamt of by the boldest thinkers of antiquity.

Since civilization is the product of moral and intellectual agencies, and since that product is constantly changing, it cannot be regulated by the stationary, i.e., moral, agent. The real agent, therefore, is the intellectual one because (1) since it is not moral it must be intellectual; (2) the intellectual principle has an activity and a capacity for adaptation quite sufficient to account for the extraordinary progress Europe has continued to make during several centuries. The intellectual principle is not only far more progressive than the moral principle, but is more permanent in its results, because its truths are enshrined in scientific language, whereas the good deeds effected by our moral faculties are

less capable of transmission, and have to be worked out by every man for himself in each generation.

Religious persecution and war are on the whole slowly diminishing. This is caused not by moral feelings or teachings, but by intellectual advance and depends on three things: (1) the amount of knowledge possessed by the ablest men; (2) the direction that knowledge takes—i.e., the sort of subjects to which it refers; (3) above all, on the extent to which the knowledge is diffused and the freedom with which it pervades all classes of society.

In the earlier centuries a blind and unhesitating credulity ruled most men's lives. Few people were more despised than the mere theorist or idle dreamer who arrogantly opposed his own reason to the wisdom of his ancestors. Such men there were but in the then state of society it was impossible that they should make any permanent impression.

All hail to the doubters and skeptics, for of such were the scientists of all ages! Progress was impossible until doubt began. Men perfectly convinced of the accuracy of their opinions never attempt to examine the basis on which they are built. Doubt must intervene before investigation can begin. Skepticism is the driving force behind civilization. No single fact has so extensively affected the different nations as the duration, the amount, and above all, the diffusion of their skepticism.

In seventeenth century England, skepticism in science led to the foundation of the Royal Society, whose avowed object was that of increasing natural knowledge by direct experiment and of combating supernaturalism; in politics, it stimulated revolution; in religion, it produced a thousand sects, each of which proclaimed and often exaggerated the efficiency of private judgment.

Buckle's views based on solid foundations are weighty and authorative, and more recent thought is in harmony with them. Professor J. Arthur Thompson in his "Introductory Note" to "The Outline of Science" may be quoted in point: "We agree with Professor John Dewey that 'the future of our civilization depends upon the widening spread and the deepening hold of the scientific habit of mind.' . . . 'And even more than science, to our way of thinking, is the individual development of the scientific way of looking at things. Science is our legacy; we must use it if it is to be our very own."

"We Visit the Moon"

PETER M. MILLMAN, PH.D.
David Dunlap Observatory, University of Toronto

November 5th, 1938

Man has always dreamed of visiting other worlds but that dream has been very far removed from practical reality. However, if scientific progress is allowed to continue in the future at the pace set during the last hundred years, it would be rash to say that man would forever be incapable of sending a projectile to some other world. If the attempt is ever made by our descendants in the distant future it is certain that our neighbour the moon will be the first "port of call". Though the moon is 240,000 miles away the term neighbour is very applicable since the nearest star is one hundred million times this distance from us.

An actual trip to the moon is impossible but we can conjure up a space ship of the imagination and visit the surface of our satellite through the agency of photographs taken with the world's greatest telescopes and the scientific knowledge of the lunar surface accumulated through centuries of observation by astronomers.

As we approach the moon, a small world just over 2,000 miles in diameter, we note that it always presents the same face to the earth, a phenomenon that is probably the result of tidal action in past ages. While still many thousands of miles from the moon the extremely mountainous character of the surface is evident. We approach it near the last quarter, and the long shadows of the setting sun throw the mountains into bold relief along the terminator. Many of these are in the form of great circular craters or walled plains.

We bring the ship down on the floor of Clavius, an immense crater 140 miles in diameter. The towering ramparts which encircle it, 12,000 feet high, are almost below the horizon in the distance. As we step from the space ship on to the lunar surface we note striking differences between our present surroundings and those we were accustomed to on earth. The sky is black and filled with stars though the sun is still above the horizon. This horizon, incidentally, is much closer than on earth owing to the greatly increased curvature on a smaller world. There is absolute silence since no atmosphere is present to carry sound. This fact also necessitates the use of space suits and oxygen apparatus though the weight of these is far from trying since surface gravity is just one-sixth the terrestrial value, which means that a man weighing 180 lbs. on earth would weigh only 30 lbs. on the moon. Walking presents quite a problem at first. In general the surface is covered by a powder similar to gray-brown volcanic ash with occasional outcrops of dark rock. The ultra-violet and x-rays from the sun strike with full force as there is no atmosphere to filter them out. The sun sinks very slowly, the period between sunrise and sunset being equivalent to a terrestrial fortnight. When the sun, with its pearly corona and flaming prominences, finally disappears below the mountain crags, darkness drops with a frightening suddenness, and with it comes the cold of the lunar night with temperatures below 250° F. The earth shines in the sky like a giant full moon, but with four times the apparent diameter of the moon as seen from the earth.

We travel over the lunar surface and find a great variety of surface features; deep valleys near the south pole between mountains rising to heights of over 30,000 feet, valleys which are in eternal shadow since here the sun is always near the horizon; great areas of darker surface (the so-called seas) some hundreds of miles across and now desolate plains but showing unmistakable evidence of erosion by liquid in the past; crevasses, the largest of which are over a mile across and 50 to 100 miles in length. Passing across the Sea of Tranquility and the Sea of Serenity we enter the Sea of Showers by the Valley of the Alps, a straight depression 5 miles wide and over 70 miles long. The peaks of the Alps rise on either side to heights of 11,000 feet. Far to the south are the Lunar Apennines, a range which stretches for 450 miles across the lunar surface with individual peaks rising to 21,000 feet. In the crater Erathosthenes at the limit of the Apennine range the late Prof. W. H. Pickering thought he detected changes in both shadings and colours which might indicate the presence of a very low order of vegetation nourished by slight vapour seeping up through cracks in the crater floor. Such hypotheses, however, are considered by most astronomers to be highly speculative and to require more definite evidence for their acceptance. It is possible that small changes have taken place on the lunar surface owing to the difference of over 400° F. between night and day temperatures and the consequent cracking and weathering of the rocks. Faint residual volcanic activity has been suggested for spots like Linne', which used to be a deep crater and now is a faint white spot. In general, however, the lunar surface is changeless century after century, and everywhere we find the great circular craters.

Leaving the moon near its full phase we look back and see systems of white rays radiating from certain craters. These cast no shadows, and the longest run for over 2,000 miles across mountain range and sea bottom without deviation to

right or left. They are apparently composed of a light-coloured material in powdered form mixed with larger lumps of the same substance but their origin is still one of the major lunar puzzles. Certain it is that they are closely connected in origin with the craters from which they radiate and the best theories indicate a tremendous shock in some past age at this centre of radiation.

And what of the craters themselves? There is much to be said for each of the two outstanding theories of their origin, viz., meteoric impact and volcanic activity. Small rows of craters seem to indicate the presence of volcanic faults but on the other hand, from the evidence we have on the surface of our own earth, it seems probable that some if not a majority of the lunar craters were produced by the impact of meteors. I myself hold a view between the two extremes and believe that some of the craters were produced by each agency, though it is still impossible to say what relative percentages we should ascribe to the rival theories.

"Anthropology and Human Behaviour"

CLARK WISSLER, PH.D.

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November 12th, 1938

Modern man is fond of saying that he has discarded superstition and magic and that he now walks in the light of his reason. He thinks he has subscribed to science as the ideal and set down superstition and magic as slanderous words of ugly implication. The scientist especially, loathes superstition with a loathing biting and deep. Long battling over the centuries against human inertia and human folly have taught him beyond peradventure that these are foemen worthy of his steel, only to be vanquished by persistent, unremitting war. This then begs the question: Have we conquered superstition and magic in our brave new world?

Well, what is magic? The laymen thinks of conjuring. The scientist, however, holds that magic is a point of view, a theory of the world in general, that a belief in magic implies that two contrasting powers can operate in the world at one time. One group of powers holds the world and man to an automatic, regular sequence of events; the other powers are believed to be humanlike, possessing intelligence, emotions, ambitions and prejudices; their chief interest is in man, for whose good or ill they may intervene to the extent of a temporary interruption of the steady grind of the natural world. Thus magic is the antithesis of science; the scientist holds that the only real powers are of the orderly predictable variety.

The truth of the matter is that despite modern man's lip service to science, many common superstitions flourish unchecked. Men walk round ladders, shun number thirteen, toss salt over their left shoulder, perform any one of a hundred and one trivial and silly acts in full knowledge of their folly, but still, "taking no chances." They observe them on the sly, "just to be on the safe side." It is a triumph of superstition over reason.

Folk medicine is another fertile field for magic. It is still with us. The corner drug store. in so far as it dispenses old line bitters, tonics and pills, is in essence a "magic shop." Most of these preparations have little direct therapeutic value; they merely promise to "ward off" a dozen and one ills the flesh is heir to.

Magic still has a foothold in our centres of culture and light. Twenty years ago a college survey showed that a large proportion of the students still performed certain acts believed to bring good grades, give security of mind, etc.,

most of which would fall under the head of magic: a four-leaf clover is prized because it brings the owner "luck," a certain charm because it brings victory in athletic contests, and so on down the list.

Nevertheless, better times are ahead. The ultra-American has travelled rapidly and far on the road from magic to science. But among the immigrant colonies in our midst, the "evil eye" and miscellaneous magical ideas imported from European folk life are still going strong.

Yet we must not be too optimistic. Magic is at bottom a type of human behaviour. When we discard the old we may be seduced by the new. Much of the old magic is doomed by its manifest childishness. but new and more subtle forms of magic lure us on.

Here is the paradox. A too childish faith in the ways of science may lead us to these new forms of magic. Many of us have already succumbed to the spell. The naive individual hears of hidden elements in food called vitamins. makes weird guesses respecting the value of certain diets, gaily formulates a slogan—and magic is off on another merry parade. Many pseudo-scientists who sedulously peddle perpetual youth nostrums to a credulous clientele would look better in an alchemist's den (or perhaps behind the bars) than in a modern laboratory.

Further, we are still far from trusting science in the matter of our emotions and in social affairs. Science is woefully weak in those fields. We need an A B C of human behaviour. We must bring order out of chaos. Science has begun the fight and will win through. The New Psychology is on its way!

Yet when a great social crisis confronts us, we are forced to jettison our pretty economic theories and resort to empirical methods, many of which are mere magic. We seem to have invested our faith in legislation per se, so we call for laws—and more laws. The answer may be read in the columns of your favourite newspaper.

There is a silver lining, a ray of hope, a saving grace, to the situation. And well we need it. When modern man is confronted by these vast stirring exigencies that seem to defy solution he chooses to wave the symbols of science rather than those of animism and supernaturalism. He lines up with the scientist rather than the medicine man. He has finally put his faith in an orderly impersonal world in which true knowledge is the only sure road to confidence and human betterment. May he never suffer betrayal! May he never falter!

"Hot Springs and Volcanic Activity in New Zealand"

Arthur L. Day, Ph.D., Sc.D.
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November 19th, 1938

Yellowstone Park, Iceland and New Zealand are the only regions in the world where we find the more powerful exhibitions of hot water circulation referred to as geysers and boiling springs. At the present time the activity in Yellowstone Park eclipses for variety, scope and intensity similar phenomena in other regions. The visit to New Zealand was made to test and eventually to corroborate generalizations arrived at after seven years' study of hot-spring phenomena in Yellowstone Park.

To the geologist, Yellowstone Park is a plateau formed by a series of eruptions of rhyolite—a high silica lava poured out in successive flows with no long intervals for soil to form or for erosion to take place between them. The rhyolite is some two thousand feet in thickness and except for joint-cracks formed by

the original cooling of the lava, is not faulted. Thermal activity in Yellowstone Park must have begun at least as far back as the last ice age.

Where does the heat come from? You cannot have continuing hot springs by merely passing cold water over hot rocks: the rocks will not stay hot. It would require all the heat from two square miles of red hot rock surface to maintain Old Faithful alone for a single year—and it has been going for several thousand years.

In our search for a source of energy, therefore, we have no choice but to turn to the magma itself. The magma has gases in solution which are released during crystallisation; and when they come out of solution they will escape upward through the joint-cracks until they encounter the circulating ground water above. This circulating meteoric water thus receives and absorbs superheat of the steam, which constitutes 96 per cent. of the original gas in the magma. Steam has a very high specific and latent heat and, when so discharged through the ground water, would be a heating agent capable of continuing for a very long time.

We know this ground water has been in contact with the original magmatic gases because it carries its record in solution, not only of all the rocks with which it has been in contact, but also elements like boron and arsenic which are not found in these surface rocks at all.

We can therefore picture Yellowstone Park as a great mountain drainage basin six or seven thousand feet above the sea, with a water supply of about 27 inches a year, well forested—which means that the surface water is conserved,—and below the surface, this continual activity taking place.

In New Zealand the formation is again rhyolite, but it is not in compact flows in the hot-spring region. Through some hundreds of feet of depth and distributed over something like eight or ten thousand square miles, the surface is really made up of volcanic ash—clastic material thrown out hot and bedded while still hot. It is only in recent years that geologists have come to recognize that there could be volcanic explosions (*nuées ardentes*) in which the erupted fluid lava carried gases *in solution* under pressure so high that even when it was thrown into the air as ash it continued to give off gases which helped to maintain a high temperature for a considerable time. In Martinique in 1902 the explosive cloud passing over St. Pierre, five miles from the centre of eruption, is estimated to have been still above 900° C. The New Zealand deposits appear to have been formed in that way out of explosive products discharged through the air and deposited while still vitreous and hot enough to coalesce. The originally finely divided material is now tightly bonded at the bottom and decreases in gross density toward the surface. Such surface material permits even freer circulation of magmatic steam from below and ground water from above than the joint-cracks of the Yellowstone flows.

The rainfall in New Zealand is about twice that in Yellowstone Park and the looser texture facilitates the circulation of water. Consequently all geyser phenomena suffer somewhat in intensity. Nevertheless all thermal activity is identical in kind with that found in Yellowstone Park. In the valleys, where the surface water reaches greater depths in its circulation, we find hot springs and geysers whose waters are clear and alkaline. On the hillsides, where ground water is scarce, gas seeps through to the surface, forming small, turbid springs of acid reaction corresponding to the original magmatic gas, and no geysers.

Hot spring activity in New Zealand is chiiefly found within an area 100 miles long by 20 miles wide, extending in a north-northeast-southwest direction across the North Island. The famous volcanic eruption of 1886 took place on and adjacent to Tarawera Mountain near the centre of that section.

The greatest geyser on record anywhere was the Waimangu Geyser which broke out later in this same area adjacent to Tarawera Volcano. From 1902 to 1905 it played a stream of hot water, mud and boulders sometimes reaching

1,500 feet into the air. It has been known to lift a boulder weighing half a ton as much as 1,000 feet in the air. It is inactive today and all traces of it have disappeared from the site. Excessive pressure doubtless destroyed it as it did the Excelsior Geyser at Yellowstone Park.

"Wilderness Wonderlands"

EARL A. TRAGER, S.B.
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November 26th, 1938

Wilderness areas comprise less than one per cent. of the national park land in the United States. In these areas every effort is made to combat the en-encroachment of man. Motor trails and other facilities for easy travel are taboo and everyone, irrespective of his place or position in life, must make his own way through these scenic wonderlands. Conditions are primitive and wild life has an unexcelled chance to prosper and maintain itself in a natural environment.

Never before has the importance of conserving these valuable areas been so realized. The purpose is twofold: to preserve for posterity our natural heritage of bud and bush, bird and flower, and strengthen a civilization that is in dire need of an opportunity to drop world affairs and business perplexities and commune again with Mother Nature.

In this streamlined age there is a basic and urgent need for a means of relaxation that will strengthen body and mind. There is ample time and opportunity today for people to do this but they must be trained to utilize their opportunity. It is the challenge of the new leisure, a challenge that is met fully by the national park system of the United States.

The varied opportunities offered by our national parks are truly magnificent. For those who like to take their travel the hard way there are tortuous trails to test their wind and muscles and rare scenic thrills to titillate their eyes. Those who wish can study nature at home and stalk dangerous game with their trusty cameras. Historic battlefields, rare geo-physical phenomena of the type found in Yellowstone Park, and the boyhood homes of those who have risen to national greatness are alike considered by the national park division worthy of preserving for posterity.

The opportunity for organized camping is now receiving considerable attention. It is unquestionably valuable in developing the team spirit which is so much needed if the individual is to co-operate with his fellows in everyday life. It is one lesson the democracies may well learn from the dictatorships.

The chief point of difference between the administration of the national parks of Canada and the United States is the provision by the United States Government of college-trained naturalists to serve as guides. This service, discontinued by the Dominion Government after a two-year trial, may be restored because of popular demand.

People who visit national parks want intelligent answers to their questions on natural phenomena, so the National Park Service at Washington provides this free guide service of botanists, zoologists and geologists to explain the natural history of the area. In Yellowstone Park there are twenty-two men.

"Safeguarding Canada's Health"

R. E. WODEHOUSE, M.D., O.B.E., D.P.H.
Deputy Minister of Pensions and National Health, Ottawa, Canada

December 3rd, 1938

In its present actual practice, the division of responsibility for guarding the health of our people is remarkably clean cut. Detailed health efforts are carried out under supervision of the Provincial Departments of Health. In most provinces it assumes the form of expert leadership and assistance through trained personnel, co-operating with the municipal public health services.

The Federal Government does, however, assume some medical or social welfare responsibilities for three groups, viz., the pensioned ex-service man or the ex-service man receiving war veterans' allowance (a much more generous form of old age pension than that operated for civilians), the North American Indians receiving treaty money, and the Esquimaux.

Dominion-wide activities of the Federal Government may be narrowed down to four fields:

1. Federal responsibilities of an international character.
2. Federal responsibilities for national purposes carried out abroad or at our borders.
3. Federal responsibilities purely national in scope and operation.
4. Federal assistance to other Federal departments and to the provinces and voluntary agencies.

Our Government co-operates with other national governments in such matters as the sanitation of international waters, the exchange of information and police assistance to combat the narcotic drug traffic, the exchange of information through the Office International d'Hygiene in Paris, a service maintained by over fifty nations to fight the spread of plague, typhus fever, yellow fever, smallpox and cholera. It also co-operates in the deratisation of ships with cyanide gas, and the hospitalization of sick mariners on all ships which come to Canadian ports.

The Federal Government assumes responsibility for the inspection of foods and drugs coming into the country, for the control of the import and export of drugs, for the control of proprietary and patent medicines sent into the country. (It has seized many "cancer-cures"), and for the medical inspection of immigrants before they are granted vizas.

Federal responsibilities which are purely national in scope include the enforcement of the Food and Drugs Act, the licensing and supervision of proprietary and patent medicines, the administration of the Opium and Narcotic Drug Act which controls trafficking in the Dominion, the protection of workers on Governmental projects outside the jurisdiction of a well-organized public health service, the hospitalization of lepers, and the creation of bodies such as the National Council on Nutrition and the proposed Medical Institute of Research.

The Department of Pensions and National Health assists many voluntary health organizations with subsidies to enable them to work more effectively in the public good. On request it lends its trained personnel to provincial governments, and it assists other countries in research problems. It co-operates with other governmental departments to safeguard the health of their employees, and has charge of the social service work for ex-service men.

Lately the subject of medical care for the masses has been much discussed and all movements in that direction closely scrutinized. The Federal Depart-

ment has had a committee of its senior officials studying the matter for the past seven or eight years, and the Canadian Medical Association and several of the provincial medical associations have such committees.

It seems reasonable to say:

1. That doctors are bound, uniformly, to desire that all people will receive efficient medical care.
2. That all doctors would desire to be assured of payment by some one for their medical services.
3. That there is nothing unethical in either of these two essentials.
4. That such a service could not possibly be carried out except with the ethical and professional features entirely under the advisory control of medical men.

Recently, too, we have heard considerable of the "haves" and the "have-nots". Now, in democracies, the "haves" may be defined as "those who have the votes." When the "haves" decide they want medical service for the masses, they have only to instruct their duly elected representatives, and the Government of the day will then instruct its officials to carry out the policy adopted. The actual administrative details present a technical problem best left to those with the necessary background and knowledge, but it is fundamental that whether or not we have such a service rests with our democratic "haves!"

All Governments are alert to safeguard the health of their people. If a proposed program, once adopted, will bring about a measure of improvement in the health of the people commensurate with the cost, and within the financial ability of the people themselves, it will be put into effect. Within these two requirements all people—*including ourselves*—may follow the direction of St. Luke, the Physician:—

> "Ask and it shall be given unto you. Knock and it shall be opened unto you. Seek and ye shall find!"

"Light and the Structure of the Atom"

M. F. Crawford, Ph.D.
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December 10th, 1938

In the past twenty-five years the many earlier speculations as to the structure of the atom have faded in the brilliancy of the miniature solar system, the atomic model devised by Rutherford and Bohr. In this development the study of the light, or radiation, emitted by the elements has played no small part; and one can justly say that many of the secrets of the atom have been revealed by the spectrograph, the instrument used by the physicist to analyse light into its constituent colours.

The spectrograph shows that when an electrical discharge is passed through the vapour of an element, as in the red neon sign, the light emitted is complex, consisting of many different very pure colours, each termed a spectral line and all of them constituting the spectrum of the element. The description of a spectrum in terms of the colours of the spectral lines is inadequate, since at best it is only qualitive and secondly many of the lines are not in the spectral region to which the eye is sensitive. Fortunately another physical property of light, which can be accurately measured, is known; it is the wave-length. Light is propagated as electro-magnetic waves, similar to radio waves, but of much shorter wave length. Further each pure colour has its own specific

wave length, which can be measured with an accuracy of the order of one one-millionth of a millionth of a centimeter. Thus the determination of the wave-lengths of the spectral lines places the description of the spectrum of an element on an accurate physical basis.

The atom, then, can be compared to a miniature radio station sending out its messages, the spectral line, in the form of electro-magnetic waves of very short wave-length, of the order of one-twenty-thousandth of a centimeter. This miniature station, however, can emit many different wave-lengths; although at one instant it can send out only one wave-length and this only for an incredibly short interval of about one one-hundredth millionth of a second. Further the complete set of signals that can be emitted by one kind of atoms is quite different from the set for another kind of atoms; in other words the spectrum of one element is quite distinct and different from that of any other element. This characteristic is the basis of a very important practical application known as Spectrographic Chemical Analysis. An element present, even in very minute traces, in a sample can be detected spectrographically by its characteristic spectral lines.

The problem of the experimental spectroscopist, then, is to record the messages sent out by the atoms by measuring the wave-lengths and intensities of the spectral lines. The problem of the theoretical spectroscopist is to decode these messages in terms of the structure of the atom.

All early attempts based on classical theory failed to account for the existence of sharp spectral lines in the radiation emitted by atoms. Bohr in 1913 gave the first satisfactory explanation, based on a dynamical model of Rutherford's nuclear atom. In the Rutherford Model practically all the mass of an atom is concentrated in the nucleus whose dimensions are very small compared to the dimensions of the atom itself. Further, for a given element the nucleus has a positive electrical charge whose magnitude, in elementary electronic units of charge, is given by the number of that element in the periodic table. The atom, which is electrically neutral, is composed of this nucleus surrounded by as many negatively charged electrons as there are units of positive charge on the nucleus. Bohr extended this to a dynamical model by postulating the actual motions of the electrons about the nucleus. The force of attraction between the positively charged nucleus and the negatively charged electron causes each electron to revolve about the nucleus in an orbit, much the same as the planets revolve about the sun. Bohr, however, introduced certain restrictions, in the form of quantum principles, which limited the motion of an electron to only certain types of the elliptical orbits permitted by classical mechanics. He further postulated that the atom emits light only when an electron jumps from one of its permitted elliptical orbits to another; and that the wave-length of the emitted light is definitely determined by the change in energy of the atom resulting from this jump, in general each different jump giving rise to a different wave-length or spectral line.

Bohr's theory, worked out mathematically in 1913 for the hydrogen atom, agreed accurately with the experimental data on the hydrogen spectrum. Since then his theory has been extended and applied to the spectra of the neutral atoms and ions of nearly all the elements with remarkable success. In this extension the original model has been revised by endowing the electrons themselves with a spin, which corresponds in our solar analogy to the daily rotation of the earth about its axis. More recent spectroscopic investigations have also shown that the nuclei of the atoms of at least some of the elements have spins, the counterpart of the rotation of the sun of the solar system. Thus our miniature solar system is practically complete, the spinning planetary electrons revolving in elliptical orbits about a spinning nuclear sun. This model devised mainly in the field of spectra has explained and correlated innumerable data not only in this field, but in other fields of physics and chemistry.

Although this model may appear fanciful, and certainly abstruse when cloaked in the mathematical formula of the physicist, yet it is built on the firm foundation of accurate experiment, and has the two fundamental features of a good theory; simplification through correlation of many apparently unrelated data, and heuristic value evident in the progress of the past twenty-five years. On these accomplishments rests our confidence in the atomic model.

"Nutrition in Toronto"

E. W. McHenry, Ph.D.

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December 17th, 1938

During the past decade the question of relief has focussed attention on the needs of low-wage family groups. Do these families, on or off relief, get enough to eat? The question is fundamental and requires a precise scientific answer.

In Toronto a privately financed committee of scientists and social workers has completed the first large-scale survey of nutrition in low-wage groups made in Canada. Its findings were not reassuring.

The field work was well and capably done. The amount of food obtained by each individual was recorded. Consequently a very detailed, accurate and authoritative factual report is now available.

The yardstick chosen to test the adequacy of the diets was the carefully prepared standard of the Canadian Council of Nutrition. One hundred families, with an average of 4.2 children per family, an average family income of $19.64 and an average, per person, weekly income of $3.48, were selected for the one-year survey.

Though the amount of food required varies with the individual, we can compute tables showing the minimal amounts of food constituents needed for health and efficiency in certain groups, e.g., manual worker, housewife, nursing mother, school child, etc.

Carbohydrates, fats and proteins are burned within the body to provide energy for us to work and to keep our body warm. Proteins also build up or replace body tissue. We need minerals and vitamins for the smooth operation of basic body processes.

The Toronto survey showed that almost one-half of the families subsisted on diets supplying less than three-quarters the energy supply regarded as satisfactory. The group as a whole received only 76.5% of the energy intake recommended as standard, while its protein intake was only 77% of standard. Our present inadequate basic knowledge of vitamins will permit no clear-cut reply, but broadly speaking, the vitamin intake was not unsatisfactory.

Inadequate supplies of iron for the women and of calcium and iron for the children were clearly indicated. It is important to note that 44% of the men and 29% of the women received calcium intakes above standard, but only a few children were in that fortunate position. Calcium is an element needed particularly during periods of growth. The high cost of milk contributes to this calcium deficiency, for milk is one of our main sources of calcium. Ordinary Canadian cheese is a much cheeper source of calcium than is milk. Cheese was used extensively by the adults in these families, particularly by the men, but not by the children. This is a pity. The popular notions that cheese is constipating and difficult to digest are entirely erroneous.

The chief conclusions reached by the survey are that only three of the hundred families secured amounts of food equal to the Canadian standard as calculated in

calories; and that while, on the whole, the men did reasonably well, one is forced to conclude that the women and children were less well nourished.

There appear to be two main reasons for this evident malnutrition. When we compare families within the group which received incomes above the group average with those below the average, it suggests—but only suggests, since corroboration has yet to be secured by analysing the budgets of high- and average-income family groups—that income is a factor in malnutrition.

The second factor tending to inadequate nutrition is lack of the necessary knowledge to choose foods wisely and economically. Mauy women are handicapped in this regard by lack of training and educational facilities to secure this training. At present the opportunities in Toronto for training adults along these lines are very meagre.

More extensive surveys in Canada are needed to provide us with additional information which can be used in planning proper educational work along the lines of nutrition. We can confidently expect an improvement in health and efficiency to follow improvement in food habits. No more pertinent quotation could be given than the brief statement made by Brillat-Savarin over one hundred years ago: "The welfare of a nation depends on the way in which it is nourished."

"The Use of Photography in the Study of Radio-Activity"

THOMAS R. WILKINS, PH.D.
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January 7th, 1939

Many of the classical experiments in radio-activity did not use the aid of photography. Even in some of these, however, the photographic technique might have been employed to advantage. The discovery of radio-activity by Henri Becquerel in 1896 was brought about by photographic means. The spontaneous radiation from any radio-active element affects a photographic plate.

In radio-activity the heaviest elements, such as Uranium and Thorium, are exploding to form simpler atoms, and in the process are firing out two types of projectiles, viz., helium particles and electrons. The heaviest of the atoms decay to form lead. In the Uranium series five successive helium rays are emitted as radium changes to lead. By soaking special photographic plates in weak solutions of radium, some of the silver atoms in the grains of the photographic emulsion will be replaced by radium. The five tracks made by five helium atoms show out as radium changes to lead. By the photographic technique we furnish direct evidence of the existence of six generations of a single atom. No longer can we think of the atoms as eternal.

We can register the decay of radio-active element by moving it slowly at a uniform speed over a photographic plate. We call the period in which the image falls off to half its value the half-life of the element.

Ordinarily we think of the heaviest elements as the naturally radio-active elements. With the exception of bismuth all elements beyond lead are unstable and decay with various types of lead atoms as the end of the decay series. There are, however, several cases of instability among the lighter elements. Potassium, Rubidium and Neodymium all emit electrons. In addition Samarium, a rare element, emits a helium particle.

The half-life of Samarium is a million, million years. It is the longest yet studied. Its radio-activity escaped detection till 1934, when Professor Hevesy of Copenhagen detected it. Samarium has several isotopes, ranging in atomic weight from 144 to 154. It seemed almost too much to hope that one might go

a step further and decide which of these isotopes was the unstable one. The photographic emulsion gave us a tool which enabled us to pin the responsibility on that form of Samarium whose atomic weight is 148. The decay of fewer than a dozen atoms in several months gave us the answer.

You may be interested to know how the experiment was done. Dr. A. J. Dempster, a graduate of the University of Toronto and now professor of physics at the University of Chicago, has developed an apparatus in which the element to be investigated forms one electrode of an arc. When current passes across the arc the element to be investigated is vaporized. Its atoms, electrically charged, are speeded up by an accelerating potential of (say) fifty thousand volts. They pass through a slit, and a magnet then bends the atoms on circular paths until they strike a photographic plate. Only those atoms of the same mass come to the same point. The lighter atoms are bent in smaller circles than the heavier ones. A typical Samarium deposit was not developed in the plate for several months. Only a minute trace of each of the Samarium isotopes had been laid down, but since we can examine the emulsions with microscopes of high magnification, it becomes possible to focus down through the deposit of Samarium and to detect the individual tracks resulting from each explosion which shot a helium particle down into the emulsion. Only a dozen exploding atoms in several months told the story.

The Age of the Solar System

For many years use has been made of the fact that since uranium decays to form lead at a known rate, it is possible to determine the age of a uranium mineral by measuring its lead content. We thus know the oldest surface rocks were formed about 2000 million years ago. Another problem challenges attack: How long is it, not since the minerals crystallized out, but how long is it since what was to become the earth broke away from the sun?

The hint of a possible method of attack came from a study of an apparent relation between two of the three families of radio-active elements. The actinium family is never found divorced from the radium family. It has long been recognized that there must be some genetic connection. At first is was thought that the Actinium series branched off part way down the line as Uranium changed to Radium. In 1926 our studies suggested an alternative, viz., that Actinium descended from a Uranium atom which decayed perhaps twenty times as fast as the Uranium which decays to form Radium.

This theory is now generally accepted as valid. Presently accepted values are that Actino-uranium decays about ten times as rapidly as the main Uranium. Their relative activity today is about 4%. Two thousand million years ago, when the surface rocks crystallized out, the numbers of atoms of the two kinds of Uranium which decayed per second would have been nearly equal, but for equality we must go back still further in time—say 2500 million years. Presumably at that time our earth was part of the sun and there—by processes which we are just beginning to understand—the two kinds of Uranium were being formed in equilibrium amounts. From then until now they have stuck together in all chemical changes, for both types of atoms are Uranium. The composition of Uranium through the ages has differed only because one of the constituents has died off more rapidly than the other.

A New Application of Photography

One of the newest applications of photographic technique is the "scattering camera" which we have recently developed. Photographic plates spaced every five degrees around a circle record the tracks of the alpha rays of radium or the protons or deuterons generated by cyclotrons as they are deflected in passing through a thin foil of metal. Such a camera promises to extend the studies initiated by Lord Rutherford to which we owe so much of our knowledge of the forces between atomic nuclei.

"Sparta in the Light of the British Excavations"

A. J. B. Wace, F.S.A., LL.D., Litt.D.
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January 14th, 1939

Throughout the Golden Age of Greek history Athens and Sparta struggled for supremacy. Athens was the City of Culture. Her superb buildings, her brilliant sculptures reflected her fastidious mind. Her philosophers and scholars fashioned a mighty tradition that could not but grow richer with the years.

The people of Sparta were of a different temper. We visualize her sons as men of blood and iron, forged in austerity. The historian Thucydides knew both cities well. He declared no visitor of the future would think a once great city ever stood on the site of Sparta, so mean and insubstantial were her buildings. The Spartans answered that men—not buildings—make a city great.

The two cities—inspired and made great by antithetical philosophies—were, curiously enough, complementary. Athens sheltered truth-seekers; Sparta defended them. In at least two historic cities it was Spartan blood and iron which repulsed the armies of Xerxes, intent on conquering the city states of Greece.

The modern apologist for Sparta can say more than that. It had long been supposed that Sparta from its very beginning had been a state without culture. British excavations at Sparta have completely reversed this view. The British School of Archaeology at Athens has traced the walls of Sparta (which were not built till the days of Sparta's decline), and has identified the outlines of its topography and excavated several of its temples and its theatre.

Most famous of the shrines found are those of Helen and Menelaus, of Artemis Orthia—at whose altar the Spartan boys underwent the ordeal of scourging—and of the Athena of the Brazen House—where King Pausanias was starved to death. In the ruins of these temples have been unearthed large quantities of archaic objects of art in bronze, ivory, pottery, gold, terracotta, silver, lead and other materials. These date from the tenth to the sixth century, B.C., and show that in the early days of Greek history Sparta was as cultured as Athens or any Greek city.

About 550 B.C., however, the Spartans changed their constitution and instituted a severe physical training for the boys and girls and made all her education a preparation for war. A strong militaristic spirit governed everything and the boys and young men were taught to regard war and military exercises as their profession. This militarism soon crushed Spartan literature and art and henceforward Sparta counted mainly as a physical force in Greece rather than as a moral power.

It is clear from the results of the British excavations that but for her turn to militarism Sparta could have been as famous in literature, art and science as any other Greek city, for the artistic promise shown by her in the archaic period is certainly equal to that of Athens.

Another point brought out by the British excavations is that it now seems most probable that Homeric Sparta stood on the site where the citadel of classical Sparta afterwards arose. This Homeric Sparta included the palace of Helen and Menelaus where Telemachus was entertained, as Homer relates, while searching for news of his father Ulysses.

The British School at Athens which conducted the excavations is the official British archaeological institution in Greece and has students from all over the British Empire. Among Canadians who have been students there and have since distinguished themselves, is Dr. Currelly, Director of the Royal Ontario Museum of Archaeology.

"The Atom and the Nucleus"

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January 21st, 1939

The classical experiments of Lord Rutherford showed that the atom had an open planetary structure consisting of a nuclear "sun" around which whirl 'planetary" electrons. It was so difficult to probe the nucleus that little has been known about it until recently.

By means of gigantic machines which put one in mind of the laboratories pictured in a penny-dreadful, sub-atomic particles such as protons or deuterons have been invested with speeds millions of times those of fast moving shells. These particles are sufficiently small and powerful to enter the nucleus and search out its secrets for the observer.

It is now possible to state that the nucleus is a tightly packed core of particles called neutrons and protons, held together by intense forces many millions of times greater than those occurring in the atom itself. The proton is a positively charged particle; the neutron is uncharged. Both particles have the same mass. The nucleus has a density a million million times that of water.

This revolutionary discovery unfolds before the scientist an entirely new region in which to pursue investigation and test contentious theories. It is his testing ground, just as Salt Lake flats are testing ground for motor cars. He is testing his theories of matter—what makes things work.

The nature of the intense forces which bind together the particles in the nucleus is at present unknown. The fact that they are there explains the nature and reason of radioactivity, something we could not previously fathom. The average radium atom exists for 2,000 years and then suddenly takes it into its head to break up, sending out from the nucleus particles of amazing energy. Who pulled the trigger? The answer is that it is a matter of chance. When a little extra energy is added to the nucleus it is shared among all the particles present and nucleus can hold this extra energy for a long time without explosions. When this extra energy collects by chance on a particle on the surface of the nucleus, the particle can then tear itself free, and we call the phenomenon radioactivity.

Scientists have gone still further. They are now able to produce intense beams of artificially energized, high speed sub-atomic particles which will prove powerful therapeutic allies to X-rays and radium in treating cancer.

While the curative action of high speed neutrons is very analogous to that of X-rays and radium, it will not replace them because the ionizing action of such particles differs from that of other types of radiation.

Rather it is a fresh tool for the radiotherapist. The whole treatment of malignant disease will be a more delicate and controlled affair because these other radiations will be available. Many institutions have already built apparatus to explore the possibilities. The construction of a machine to produce artificially energized particles is under way at McGill University and Queen's University contemplates constructing one.

"The King Township Survey"

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January 28th, 1939

A survey of the natural resources of King Township, York County, made in 1937, showed that during the hundred years of settlement the water supply was tragically lowered, that seven-eighths of originally permanent streams had dried up or become temporary, that wild life had been seriously depleted, that there had been a steady falling off in local industries, such as sawmills, woollen mills and grist mills, and that the population had receded from a high point of 7,500 to the present 4,600.

King Township, an 80,000-acre area about twenty miles north-northwest of Toronto, constitutes a random sample of conditions in older Ontario, and the results of the survey show that we are faced with a vast social problem of immediate urgency.

The facts revealed by the survey form the basis of a plan to create stable conditions in the township and to bring it to such a state that its renewable resources, trees, crops and wild life, together with its water and soil, may recover during the next twenty years or so a large measure of their earlier vigour. The plan involves reforestation of selected areas, management of existing woodlots, and water and erosion control.

Expenditure of public monies on large scale conservation will bring assured returns. Here is an investment form of relief that will help to restore and maintain the country's natural resources on a permanent income-producing basis.

The report is publishel in full in the Transactions of the Institute. Members may obtain a copy from the Secretary.

"The Manufacture of Plants"

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February 4th, 1939

The problem of supplying food and other necessities of life to the two billions of people in the world constitutes the primary reason for continued efforts to produce new plants. There never has been, and likely never will be, a surplus of food if everyone receives all the nourishment he needs.

The old idea that we simply need enough food to prevent starvation no longer holds. Many diseases once not attributed to malnutrition may be traced to it. A survey of Great Britain showed that one-half the population was under-nourished. One might expect a similar survey in Canada to give similar results, though probably to a less marked degree.

Cereal seeds form the basis of the world's food supply. Of these rice and wheat are the most extensively used. About five billion, six hundred million bushels of wheat, and approximately the same quantities of rice, are used annually. Nearly five pounds of grain are required to produce one pound of meat.

For this reason, in countries with dense populations or limited resources, it is economically unsound to eat meat.

Increasing quantities of plant products are used in manufacturing. In building a million cars, one manufacturer uses over two million, four hundred thousand pounds of linseed oil, one-half million bushels of corn, three million, two hundred thousand pounds of wool, one million, five hundred pounds of leather, eighty-nine thousand pounds of cotton, two million pounds of soybean oil, and two and a half million gallons of molasses.

Plants, like human beings, have basic needs, viz., air, water, food, etc. However, they differ greatly in their ability to perform the various functions necessary for growth and development. This gives an opportunity for progressive selection in the direction desired. There has been an increasing interest in experiments demonstrating the possibility of producing plants by soilless culture to determine the effects of various quantities of both little known and well known elements on the development of plants. Little known elements are important in animal and plant life. Milk deficient in phosphorus resulted in one case where the fodder lacked that element. This was corrected by mixing di-calcium-phosphate with the fodder.

In the last fifty years hybridization as a fore-runner of subsequent selection has become the recognized procedure in breeding new plants. An outcross brings a diversity of types from which those suitable to found a new strain can be selected. Great care is then taken to keep the strain pure and to weed out undesirable traits. For example, before any new variety of wheat is released in Canada for general use, very painstaking field and laboratory tests are carried out.

The work of plant breeders has a very definite effect on the national economy. The early history of western Canada was directly moulded by the ability of plant breeders to produce wheat that would grow well under western conditions. The most serious conditions there are drought, early autumn frosts, and attacks of the black stem rust. The development of the Red Fife and Marquis wheats was one of the early and fundamental steps in establishing the western Canadian Prairies as recognized wheat producing areas.

In recent years one of the greatest contributions of plant breeders has been the development and introduction of disease-resistant wheats. Reports received from western Canada last July indicated that conditions were exceptionally favourable for the development of a very severe rust epidemic, and with the varieties commonly grown ten years ago, a very heavy loss would have occurred. particularly to the growers in Manitoba and eastern Saskatchewan. Because of the introduction of several new stem-rust-resistant types during the last five years, this loss was avoided, and millions of dollars saved for the prairie farmer.

Certain areas of eastern Ontario have for years found it difficult to raise a satisfactory crop of oats because of the presence of crown rust. Quite recently the Ontario Agricultural College at Guelph, and Macdonald College in Quebec, have put out two varieties of oats resistant to this disease. Both of these varieties have given very satisfactory yields under the conditions where oat growing was far from profitable.

These are a few of the many successes of the plant breeder. Hundreds of types of plants have been developed for particular conditions. The older varieties and strains have practically all had to make way for newer developments, and many plants are now being developed which give every promise of being worthy successors to those now being introduced or commonly grown.

"Psychology and the Day's Work"

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February 11th, 1939

In recent years it has been recognized that to ensure the future of our industrial civilization and the success of the individual plant, we must supplement the development and utilization of labour-saving mechanical devices by a more complete and effective utilization of human energy and abilities and of the human will-to-work.

To this end, psychology has been used to promote the adjustment of the worker so that he will be happy at his task, and to increase efficiency by decreasing the cost of production, the cost of accidents, and other related items.

Careful selection of workers by scientifically-sound tests helps to accomplish this. It minimizes unnecessary transfer of workers from job to job which is accompanied by the heart-breaking disappointment which comes from not making good on a job after a trial period of service.

To co-workers, especially in hazardous occupations, it is comforting to know that new workers will not, by reason of incompetence, contribute further to hazards inherent in the job. From the viewpoint of management, the contribution to increase in productive efficiency and the reduction of production, accident and allied costs, is sufficient justification for the introduction of such procedures.

ACCIDENT PREVENTION.

A psychological approach in accident prevention shows that accidents do not distribute themselves by chance. Men who have accidents in one year will continue to have accidents in other years unless appropriate steps are taken to overcome the conditions which make them particularly susceptible to accidents.

Our highways are cluttered up with private operators who cannot drive properly because they were never taught properly. Six habits, if properly "set" during the learning period, would do more to reduce accidents than the efforts now put into browbeating or frightening drivers into operating in conformity with regulations which have little bearing on the accident problem.

The six habits are: (1) Consistently remaining twenty-five feet behind the car ahead when driving on the open road. (2) Making certain there is a clear road ahead and ample room for passing before passing a car. (3) Slightly decreasing speed when passed by another car. (4) Applying the brakes before disengaging the clutch. (5) Braking the car and then coasting slightly ahead before coming to a final stop when followed by another car. (6) Properly signalling at all times—even in cold weather.

For experienced drivers, driving clinics should be established, and they should be urged to visit these clinics for an analysis of their driving habits. However, mechanical tests which purport to tell the driver's deficiencies, and which have been extensively used by automobile clubs and insurance companies are not of practical value.

To the scientist, it is clear that women are more "accident-prone" than men. Preliminary investigation throughout the United States showed that women had a smaller proportion of accidents as compared with men, than one would expect on the basis of chance. This did not take into consideration, however, that in bad weather the wheel would likely be turned over to a man; that the mileage and

night driving done by men would be greater, and that men, rather than women, were selected to drive trucks and other vehicles especially difficult to drive.

A more or less crucial experiment settled the problem. In Philadelphia two cab companies operated, one employing only women drivers, the other, only men. Both were selected with equal care, the women operated under somewhat better conditions and their equipment was a little bit better than the men's. And yet they were responsible for three times as many accidents per thousand miles of operation as were the men.

This difference in ability may not be due to difference in innate capacity as much as to the fact that the present generation of women drivers started to form these motor skills at a later age than did the men. Therefore, since there is great similarity nowadays between the training of boys and girls, this difference in driving capacity may disappear.

The Machine Age.

Studies by psychologists here and abroad show clearly that much of the blame levelled against work with machines is wrongly directed. They indicate, for example, that machine work, repetitive work at an imposed speed and rhythm, is not invariably accompanied by an overwhelming and depressed feeling of monotony. Psychological study has failed to confirm the point of view that the human mind is dulled, emotional maladjustment seriously intensified; or broader social participation hindered by repetitive work.

Conditions today combine to give the worker opportunities for relaxation, self-expression and creative experiences outside of working hours beyond the scope of anything that existed in earlier ages. The problem, then, appears to be largely one of encouraging and educating workers to take advantage of these opportunities.

Its solution may involve an attempt to substitute more productive and creative experiences for the automobile ride, the baseball game, the movies, the radio, which at present seem to occupy the spare time and the mind of the American worker. It is to the development of a program to stimulate such substitution, rather than to the critique of mechanization in industry, that the attention of the social reformer should be directed.

And if, in spite of education for the use of leisure, most men and women continue to find adequate satisfaction in the simpler and less creative forms of relaxation, this in itself may be evidence that creative experience is something which today, as in the past, is craved by only a few selected spirits.

"Biology and Civilization"

C. Leonard Huskins, Ph.D.
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February 18th, 1939

We know that seven great civilizations—each lasting about a thousand years—have been born, have flourished and have died. We differ from past civilizations in that we have placed our faith in the scientific method. The question is: will science save us?

It will if we can develop and apply a *scientific humanism*—in distinction to the classical humanism to which we are often exhorted to return. People who say we have too much science do not really mean that at all. They mean we have too much of one kind of science—applied mechanical science. They forget we have too little of the true spirit of science—the attitude of inquiry—and too little exact knowledge of the whole nature of man. We must help man to discover

himself. If we can do that we may survive. When people realize a danger they can generally outface it.

Two biological problems which challenge thought today are the effect of total population changes on world affairs, and of changes in the composition of populations being brought about because our civilization reproduces least from the type of people it most highly regards.

Falling birth rates in the democracies are at present coupled with rising birth rates in the dictatorships. *If present population trends continue,* the population of Great Britain will fall from 45,000,000 to 35,000,000 in the next thirty-five years; in Italy it will rise from 43,000,000 to 60,000,000 in the next twenty years; in France it will drop from 42,000,000 to 30,000,000 in the next thirty-five years.

The effects of differential birth rates within a population are harder to assess but there is clear evidence that they were significant in the downfall of Rome, and the data available from Great Britain today on the relationship between occupation, birth rate and ratings by intelligence tests are very disquieting.

It might be well to state in conclusion the opinion that the ideologies of the dictator states—so inimical to the inquiring attitude of science—are a greater danger to western civilization in its broadest aspects than are the wars they threaten. In conditioning their people to unquestioning obedience, dictators suppress that freedom of thought which is the fountain-head of science and the foundation of western culture.

"Polaroid"

The New Control of Light

George W. Wheelwright III, M.A.

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February 25th, 1939

Polaroid light-controlling material is a new substance that makes it possible to see three-dimensional motion pictures in full colour, produce illumination without glaring reflection, and the automobile headlight glare problem, and create brilliant new colours in colourless cellophane. It is the invention of a young Boston scientist, Edwin H. Land.

Mr. Wheelwright held two transparent Polaroid discs in front of his face, on which a light was directed. As he rotated one of the discs, his face was gradually obscured until it was blacked out completely by the previously transparent discs. The lecturer explained this ability of two Polaroid sheets to stop light as a "crossing" of their invisible "optical slots."

Scientists think of a beam of ordinary light as being like the random waves moving helter-skelter along a rope tied at one end and moved about in all directions at the other. If such a rope is run through a gap in a picket fence, all the vibrations will not get through, but only those that are parallel with the gap between the palings.

In practice, Polaroid material acts as the light beam's "fence." After light has passed through Polaroid material all its vibrations are arranged in parallel lines. If a second Polaroid "fence" is placed in the path of the light with its pickets at right angles to that of the first Polaroid element, the vibrations cannot pass and no light gets through.

Actually the Polaroid slots are minute, invisible crystals—iodo-sulphate of quinine—so small that they cannot be seen under a microscope. There are billions of them in every square inch, all embodied side by side, pointing all the same way, in the transparent sheet.

The ability of the material to eliminate glaring reflection is based on the fact that this glare is caused by light waves that bounce horizontally from the surface you are looking at, skipping off the surface just as a flat stone will skip off the surface of water, striking the eye as a mirror reflection of the light source. The useful light, on the other hand, consists of vertical waves in the same light beam that penetrate the surface of the reading matter or paper, absorb the message of colour and detail, and convey it to the eye. When Polaroid material is placed in front of the light source all the glare-producing waves are absorbed and only the useful rays are permitted to get through to the surface that you are looking at. A desk lamp has been developed which illuminates the glossy pages of a magazine brilliantly, yet without any sense of brightness, since glare has been completely eliminated.

Special Polaroid spectacles were distributed for viewing the three-dimensional motion pictures in full colour, the first of the kind seen in this area. A simplified outfit which will enable amateurs to take and project their own still three-dimensional pictures in full colour has been developed.

Colourless cellophane placed between Polaroid sheets assumes all the colours of the rainbow. The colours change completely as one Polaroid sheet is rotated. Normal light contains all the colours in the spectrum. A combination Polaroid and cellophane "sandwich" breaks down the colours, capturing and holding some, destroying others. Colours are controlled by varying the thickness of the cellophane which forms the centre of the sandwich.

The same general method can be employed in testing glassware for strains. Improperly annealed glass, or glass deliberately strained for special purposes, will show the strain lines in colour when it is placed between two Polaroid sheets. Moreover, engineering models made of transparent materials can be tested for stress by applying pressure at desired points. It is then possible for an engineer to tell how the actual structure will react under working conditions.

The principle of light control employed by Polaroid material is some 250 years old. It was never more than a laboratory curiosity until Polaroid was invented. A whole new field of applied science has been thrown open for exploration. Hundreds of uses have already been discovered for this strange new material.

"Research and Industry"

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March 4th, 1939

The intrinsic value of scientific research is beyond debate. The scientist has carried the day by sheer merit. To question the happy relation between science and society is a thankless and precarious task. Nevertheless, if we are to diagnose and correct many of the perplexities of this scientific age, we must revalue again the relation between research and industry.

The economic effect of industrial research is to increase the amount of goods that can be produced by labour during a given unit of time, e.g., the man-hour. This result is *per se* desirable. Its implications are less reassuring. The moment an increase in the productivity of labour takes place society is forced either to reduce the number of man-hours worked or to increase the consumption of commodities, or both. It is usually assumed that our economic machine will automatically adjust itself to any increase in the productivity of labour by transforming the increase completely into increased standards of life and degrees of leisure of the community.

Is the assumption justified? If we consider the first alternative, the reduction of man-hours worked, we see that the objective may be achieved in two distinct ways. We may reduce the number of hours everyone works (i.e., increase leisure) or reduce that percentage of our population that works at all (i.e., increase unemployment).

When we consider the second alternative, an increase in the consumption of goods (i.e., an increase in the standard of life), we come to the crux of our difficulty. The only way goods can be consumed by a community is for them first to be sold by the producers to the consumers. It has been argued that, if the output per man-hour increases, costs of production (and, hence, prices) will fall, and so more goods will be sold, thus automatically disposing of the results of increased productivity.

This argument is qualitative and ignores the fact that any adjustment must be quantitative if it is to be effective. It is not sufficient to show that there exists in our economy a mechanism which tends to increase the market as science increases the productivity of labour. Economic questions *must* be discussed in quantitative terms. If science doubles the output per man-hour the necessary condition, if equilibrium is to be maintained, is that the market should double also. To assume that our economy fulfills this condition is equivalent to postulating that there always exists a linear relationship between our capacity to produce and the aggregate market (the total purchases of all consumers) and that if we plot either of these variables against the other in suitably chosen units the result will be a straight line passing through the origin and inclined at an angle of 45° to the axes.

The more we examine this assumption theoretically the more improbable it appears. The first of our variables—the capacity to produce—depends on the making of countless inventions and scientific discoveries; events which are scattered erratically through space and time, and it will thus increase in an entirely incalculable manner. Yet to conform to the above postulate we are forced to assume that the other variable—the size of the aggregate market—will miraculously increase in exact proportion to such rises in the productivity of labour.

The aggregate market depends on the innumerable wants of the community, the amount of money people have to spend, and on the prices of the goods they wish to buy. These last two terms we can call purchasing power. The nature of this complex entity is so dissimilar to that of the productivity of labour that at first sight we might be pardoned for doubting if there existed any connection between them at all, let alone the mathematically precise one that is essential to maintain equilibrium. Yet this is what we have assumed in the past, and what we continue to assume if we are to urge the prosecution and expansion of scientific research with a clear conscience.

Because, if this linear relationship does not hold, the real curve connecting the two variables can only deviate from the diagonal in one direction. The aggregate market cannot increase at a greater rate than our productive capacity, for we cannot consume more than we produce. It follows, therefore, that if the real curve deviates from the diagonal it must lie between it and that axis on which is measured our capacity to produce; in which case we would be forced to reduce the number of man-hours worked to balance our production and consumption.

This is not something we can do. It is something we are forced to do. If, for example, science doubles the output of labour and the market increases by only fifty per cent, we have no alternative but to reduce the number of man-hours worked by a quarter.

To achieve this end we have, theoretically, a choice between increasing the amount of leisure by shortening the working day and increasing unemployment by reducing the percentage of people who work at all. In practice there is no

such choice. The increase in the output of labour is brought about by an almost infinite number of small advances which take place at irregular intervals in isolated industries. There exists no economic mechanism which is capable of co-ordinating the length of the working day, the effects of such advances and the size of the aggregate market. The shortening of the working day can only be brought about very slowly and never with the precision necessary to maintain equilibrium.

Unfortunately none of these difficulties lies in the way of laying men off. Therefore, unless the straight line relationship heretofore cited holds good, the result of research must be an increase in unemployment. We would only be justified in accepting the straight line relationiship on strong empirical evidence. This evidence is sadly lacking. We are forced to conclude that further research, and still more, its intensification, must have the result, as things stand, of increasing unemployment.

The mental attitude of the scientist to this situation is a most important factor. In earlier days while science was fighting for recognition the pressure of more immediately important matters resulted in the scientist neglecting the question of the relationship between markets and productivity. Today, when the value of research is self-evident, we should examine exhaustively this neglected question.

Our economic machine does not appear to distribute purchasing power in proportion to the increase in output brought about by scientific research. Until we are able to uncover with certainty the reasons why our economic machine does not increase the market *pari passu* with our capacity to produce, we must face the fact that our behaviour as a community will become increasingly irrational.

Cobblers will sit idle while people need shoes. Textile workers will struggle on relief while people need clothes. Food will be destroyed while people go hungry. People will be paid not to raise hogs and cotton. There is no limit to the idiotic shifts and expedients we will be forced into if we do not solve the problem of arranging for the aggregate market to keep pace with our capacity to produce.

Unless we can solve this problem, the relation of scientific research to industry will not only remain the unhappy one that it is today, but will have the effect of intensifying our economic confusions to the point where ultimately a breakdown must come.

"Explorations in the Nahanni Mountains (Snyder Range) in the North-West Territories of Canada"

H. F. J. Lambart, B.Sc., D.L.S., F.R.G.S.
Geological Survey, Ottawa

March 11th, 1939

Penetrating the little-known Nahanni Mountain area—five hundred miles north of the Peace River District—by boat and plane, an exploratory and mapping party surveyed in 1937 one hundred square miles of territory and plans to complete the survey of two thousand square miles this coming summer from the air. The members of the party were:—

Col. and Mrs. Harry Snyder (for 10 days only).
Stanly McMillan (Pilot, Mackenzie Air Service, Ltd.).
George Goodwin (Biologist, Assistant Curator American Museum of Natural History, New York City).
H. F. Lambart, engineer and surveyor.
Jim Ross, in charge of party.
Ted Boyton, cook.
Jow Kellis, camp help.

The expedition ascended the South Nahanni River to the Virginia Falls, which have a straight drop of three hundred feet. It then entered the Snyder Range, eighty miles further north and west. Very little is known of this region. It constitutes a portion of the main range of the Mackenzie system, which is the watershed of the two great rivers of the north, viz., the Mackenzie, entering the Arctic Ocean, and the Yukon, flowing into the Behring Sea. The surveys completed show snow-clad mountains over nine thousand feet in altitude and very extensive snow fields and glaciers of which very little is known indeed.

The Nahanni Mountains, have been renamed by the Dominion Government the Snyder Range, a tribute to Col. Harry Snyder, Montreal promoter, who sponsored the expedition. The highest peak discovered, 9,045 feet in altitude, will be named after the late Sir James MacBrien, former head of the Royal Canadian Mounted Police.

From the air, this vast mountain and glacier region presents a forbidding picture of huge saw-toothed ranges extending for many hundreds of miles in quiet and unbroken dignity. Hitherto only trappers and Indians have penetrated the district, as swift and dangerous rivers were the only means of access.

Wild life in the area is protected by the Dominion Government, and only Indians are permitted to shoot game. The expedition was given special permission to secure museum specimens. Grizzlies, black bears, cariboo, moose and the rare black-tailed mountain sheep are found.

"Defense Against Chemical Warfare"

LIEUT.-COL. HAIG SHEKERJIAN

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March 18th, 1939

One late spring afternoon in 1915, a hazy yellow fog drifted with grim certainty over the Belgian landscape near Ypres and slowly settled in the Allied trenches. The Canadian troops stationed in the sector struggled in a maelstrom of blinding, lung-searing chlorine. With indomitable courage they repulsed a succession of attacks till technical aid could be summoned from Paris and London to provide for efficient means of protection. It was the first time poison gas had been used effectively in modern warfare.

The use of gas projectiles was thought to have been barred by international convention in 1899 and little consideration had been given by military staffs to the employment of gas. They now began to study the value of this new weapon dispassionately. But to the civilian, who seems incapable of viewing war in its true character, it seemed irrational, horrible. He magnified its dangers. Alarmist reports fed his imagination. Recent events show this attitude is still prevalent. Is it justified?

Briefly, five types of "gases" are used in modern warfare. The first of these is the screening smokes, which may be breathed without any great discomfort. Their purpose is to conceal military operations.

Then there are the tear gases. These cause a copious flow of tears but a good pair of eye goggles is sufficient protection.

The third group is the irritant smokes—generally arsenical compounds. They disable a man for 24 hours but leave no lasting injury. A good mask is adequate protection.

The lung irritants are a more deadly type. Phosgene is typical of these. They blow away in the field, so an attack on a city would require an immense number of bombs. A mask gives full protection.

Finally there is the skin-blistering group. In this class mustard gas is typical. Mustard was and is the most dangerous of war gases. It is a dark brown heavy oily liquid very much like crank case oil in appearance. It has a noticeable garlic-like odour and evaporates very slowly. In either liquid or gaseous state mustard is very dangerous to body tissues. Prolonged exposure to the gas will cause severe skin blisters. If breathed without a mask it will cause serious lung injury or even death. A man working in a mustardized area needs mask, boots, coverall and gloves of some impervious material such as rubber. In a temperate climate contaminated ground may remain dangerous for weeks. It can be neutralized by chloride of lime. Since it can be sprayed from the air it represents a real threat to any target open to attack in that way.

Recent events suggest that aerial bombardments far behind the line of battle will be part of the next big war. Will gas be used in these bombardments? To the American and British mind, a wanton attack on a city is a loathsome idea. This feeling may not be shared by nations with a more aggressive military policy. One must therefore fall back finally to the proposition of military utility.

All military experience with war gases teaches us that these agents are paralyzingly effective against the unprepared, but that on the other hand no weapon of warfare can be so well countered by well conceived protective measures. The military advantage to gassing a well protected city would probably be most questionable.

Alarmists assert that in future wars huge bombing planes carrying chemical agents will so drench cities and towns with gas that their entire populations will be blotted out. Such statements are absurd. An attack with high explosive would cause much more destruction.

However, forewarned is forearmed. As stated above, the possibility and seriousness of gas attack vary indirectly with the degree of preparedness. Bombproof and gasproof shelters should be provided. Gas masks and degassing squads should be on hand. Defensive aircraft, antiaircraft guns and other devices should be developed. The public must be able to act coolly and intelligently in time of crisis. The British Air Raids Precautions Committee is doing scientifically sound work that is certain to produce important results.

In conclusion, we must dismiss our picture of the military chemist as a mysterious being working to destroy society. He is really drawing the fangs of chemical warfare, delimiting its deadlines and bringing within controllable bounds what might otherwise be a very serious threat to modern society and the sovereignty of nations.

"Vikings of the Sunrise"

PETER H. BUCK, M.D., CH.B., D.S.O.
Anthropologist, Bernice P. Bishou Museum, Honolulu, Hawaii

March 25th, 1939

Shaggy, brawling, blue-eyed men were the Vikings. They roamed the treacherous North Atlantic and the dramatic zest of their approach to life has made them a byword for elemental courage. The Vikings of the Sunrise were men of different aspect, no less brave, no less gifted for the task they took upon themselves, the creators of a great cultural heritage.

The Vikings of the Sunrise were the dark-skinned, tall, athletic, Europoid race which emerged from the cradle of mankind we call the Malay Archipelago during the stone age and swept out to people the star-scattered islands of the South Pacific—those islands we now call Polynesia, i.e., the many islands.

To accomplish this they made many oceanic voyages in double canoes, travelling in many instances over a thousand miles without touching land. Although the long sea voyages ceased centuries ago, a rough idea of the size of the ships may be formed from the vessels recorded by early European explorers. Various accounts indicate a general length of from sixty to eighty feet, but vessels were seen that measured a hundred feet and even more. On voyages for settlement the large canoes would accommodate sixty or more passengers with sufficient provender and water to meet their needs while afloat.

The Polynesians have been termed the greatest navigators of all time. There is good advice to show that one of their number steered his outrigger canoe four thousand miles by the stars across the Pacific to Peru, and then returned to his island home.

A poetic race, gifted in song and story, rich in legend and tradition, they were steeped in a transcendent philosophy. Man moulded fate; God helped those who helped themselves. Their philosophy was in sharp conflict with the traditional philosophies of the East and was an important factor in their history.

Polynesian seamen were unhampered by the mutinous fears that obsessed the crews of Columbus and later European navigators. If ships and men were lost, other navigators did not blame the gods or the sea. The lost navigator was entirely to blame for overlooking some ritual observance. Later navigators followed to accomplish what others had failed to do. Faith in their gods and their ships and confidence in themselves made the Polynesians the master mariners of the Pacific.

Their philosophy is epitomized by this Polynesian Deep-Sea Chantey:—

The handle of my steering paddle thrills to action,
My paddle named Kautu-ki-te-rangi,
It guides to the horizon but dimly discerned,
To the horizon that lifts before us,
To the horizon that ever recedes,
To the horizon that ever draws near,
To the horizon that causes doubt,
To the horizon that instils dread,
The horizon with unknown power,
The horizon not hitherto pierced,
The lowering skies above,
The raging seas below,
Oppose the untraced path
Our ship must go.

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OF THE

Royal Canadian Institute

SERIES IIIA SESSION 1939-1940 VOLUME V

PREFACE

This publication is issued with the object of conveying a general idea of what The Royal Canadian Institute endeavours to do, as well as what it has done in the past, along with an outline of each lecture given during the 91st Session 1939-1940.

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Historical Note

ON June 20th, 1849, a small gathering of surveyors, architects, and civil engineers, practising in and around Toronto, met in the office of Mr. Kivas Tully, to form an association of members of the three professions throughout the province. Out of this grew the Canadian Institute.

The original members of the Institute were William E. (later Sir William) Logan, John O. Brown, Frederick F. Passmore, Kivas Tully, William Thomas Ridout, and Sandford (later Sir Sandford) Fleming. Of these, Sir Sandford Fleming, the originator and founder of the Institute, was the last survivor. He died on July 22nd, 1915, 66 years after its foundation. The association was incorporated by Royal Charter, granted on the 4th of November, 1851, and became known as the "Canadian Institute."

Sir William Logan, who was the first president of the Canadian Institute, was succeeded in 1852 by Captain (afterwards General Sir J. Henry) Lefroy, R.A., F.R.S., Director of the Imperial Magnetic Service in Toronto, and later Governor of Tasmania and of Bermuda.

Beginning with the year 1851, there was published by the Institute "The Canadian Journal: A repertory of Industry, Science and Art," under the editorship of Henry Youle Hind, who had conducted explorations in western Canada, and was then Professor of Chemistry in Trinity University. In a later series the Rev. Henry Scadding, D.D., who was president of the Institute from 1870 to 1876, published his well-known series of "Collections and Recollections on Toronto."

Weekly meetings of the Institute have been held consecutively each year from November to April since the Royal Charter was granted in 1851. At the earlier meetings, papers on scientific problems of the day were read and discussed, and practical work was carried on by the various sections which were under the administration of the Institute. The most outstanding of these were the Biological Section, the Geological and Mining Section, and the Historical Section.

About the beginning of this century, it was felt that the discussion of scientific papers did not convey to the public the benefit of the knowledge involved in them, nor the important results that had been attained. In order therefore, to establish a more direct communication with the public, the system of weekly Saturday evening lectures was begun, with the object of directing the attention of the people to questions of public interest and utility on which scientific opinion might have an important bearing.

A few of the accomplishments of the Institute are to be found on the following pages, and from them it may be seen that the objects of the charter, granted in 1849, have been pursued steadily ever since.

On the 2nd of April, 1914, His Majesty the King granted permission to change the name to "Royal Canadian Institute."

Some of the Outstanding Accomplishments of the Royal Canadian Institute

1. Co-operation in promoting the meetings in Toronto of the following scientific societies:

(a) The American Association for the Advancement of Science, 1889 and 1921.

(b) The British Association for the Advancement of Science, 1897 and 1924.

(c) The International Geological Congress, 1913.

(d) The International Mathematical Congress, 1924.

2. Standard Time.

In 1878, Sir Sandford Fleming brought forward the plan of adopting for the whole earth, twenty-four standard meridians, fifteen degrees apart in longitude. He published many papers on this subject, and with the co-operation of the Institute, the zone system of time-reckoning was adopted in most of the countries of the world.

3 The Museum.

The Ontario Archaeological Museum was begun under the auspices of the Institute, and continued under its management for six years, before being transferred to the Ontario Government and the University of Toronto.

4. Publications.

The Publications of the Institute have appeared in four principal series and one minor series as follows:—

(1) "The Canadian Journal: a Repertory of Industry, Science and Art," and a Record of the Proceedings of the Canadian Institute. 3 vols., 4to. Begun August 1852, ended December, 1855.

(2) "The Canadian Journal of Science, Literature and History." 15 vols., 8vo. Begun January, 1856, ended January, 1878.

(3) "Proceedings of the Canadian Institute." 7 vols. Begun 1879, ended April, 1890.

(4) The Archaeological Reports of the Canadian Institute was published as part of the Appendix to the Report of the Minister of Education for the Province of Ontario. 1886-1904.

(5) Minor Series. "Proceedings of the Canadian Institute." From 1897 to 1904, two volumes of this series, containing short papers, were published.

(6) "Transactions of the Royal Canadian Institute." Begun October 1890, and up to October 1940, Part I of the twenty third volume has been published. This publication contains scientific papers on technical subjects, relating to all branches of science. These papers are submitted by those doing research work. The publication is sent to learned societies throughout the world, and these societies send their own publications in exchange. Any Ordinary member of the Royal Canadian Institute may receive a copy of this publication upon request.

(7) "Proceedings of the Royal Canadian Institute." Series IIIA. Abstracts of the lectures given during the year. Begun 1936 and to date five volumes have been published.

(8) General Index to Publications 1852-1912. Compiled and edited by Mr. John Patterson. Dr. J. B. Tyrrell, President of the Institute, 1910-1913, undertook to finance the compilation of the index, and made it possible for the Council to proceed with the work.

5. The Library.

As a result of the exchange of publications with learned societies for the past ninety-one years, the Institute has built up a most important scientific library of over twenty-five thousand volumes, many of which are indispensable to scientific workers in this part of Canada. For protection against fire, this library is housed in a section of the library of the University of Toronto, and may be used by the staff and students of the University as well as by members of the Institute.

6. The National Research Council and the Ontario Research Foundation.

It was in large part due to the vigorous campaign of the Institute, on behalf of a wider application of science to industry in Canada, that the Honorary Advisory Council for Scientific and Industrial Research, the forerunner of the National Research Council, was appointed by the Dominion Government, and that the Ontario Research Foundation was instituted through the co-operation of the Ontario Provincial Government and manufacturers.

7. University Grant.

The Institute also strongly supported the successful application to the Provincial Legislature for an annual grant for research in the University of Toronto.

Report of the President

1939 - 1940

As presented to the Annual Meeting, Saturday, April 6th, 1940.

Throughout its long history the character of the Institute and its work has changed to meet changing needs. A review of the past year's work will indicate what the Institute is now attempting to do and how it is attempting to do it.

LECTURES: The Institute's chief aim is the promotion of science and the spread of scientific knowledge. Our series of popular Saturday evening lectures is one of our most important contributions to the spread of knowledge of the results of scientific research. Leaders in all branches of science glady co-operate with us in this important work by lecturing before us. During the past season we had only eighteen lectures as compared with the usual twenty. This resulted from the unusually early date on which Easter fell this year. The subjects dealt with in this year's series included:—Anthropology 1, Archaeology 1, Astronomy 1, Engineering 2, Chemistry 2, Geology 2, Industry 2, Mining 1, Natural History 2, Physics 3, Zoology 1. Abstracts of all lectures are included in the present number of the "Proceedings." Six of the lecturers were from Toronto, six from Canada outside Toronto, and six from the United States. The average attendance was 950.

The newspapers of Toronto have, us usual, been generous in announcing and reporting the lectures. Although brief newspaper reports are not nearly as valuable as lectures in bringing about an understanding and appreciation of science and scientific advances, yet much greater numbers are reached through the medium of the press. I believe the Institute could render a valuable public service by bringing about a closer co-operation between science and scientists on the one hand, and the press on the other, so that science is given more adequate publicity in newspapers.

PUBLICATIONS: Another of the Institute's important contributions to the advancement of science is through its publications. These consist of "Proceedings" and "Transactions" During the year Volume IV, Series IIIA of the "Proceedings" and Part 2 of Volume XXII of the "Transactions" were published. The Institute owes a deep debt of gratitude to our editor, Dr. E. M. Walker, who has edited its publications so effectively for fifteen years.

LIBRARY: Still another contribution of the Institute is the maintenance of a valuable scientific library. The journals and other publications contained in our library are received from scientific societies throughout the world to which our publications are sent in exchange. During the year our "Proceedings" and "Transactions" were sent to 486 societies and other

scientific institutions. This is a decrease of 49 from last year, due to the fact that publications have not been sent to Germany and other countries now controlled by Germany. In return the Institute receives 1009 publications yearly from 486 societies and institutions. Sixteen new exchanges have been recorded during the past session.

As reported in previous years, our library is stored in part in three different places,—in the University of Toronto Library 10,820 books, in the basement of University College 5,229 books, and in the Institute building at 198 College Street 1469 books. Such an arrangement interferes greatly with the usefulness of the library to scientific workers. There is an opportunity here for some one to render an outstanding service to science in Toronto and incidentally to erect a permanent memorial to his name by providing the Institute with a building adequate to house its library as well as its administrative office.

The care of the library is under the supervision of Professor E. Horne Craigie, our librarian, who has devoted a great deal of time and energy to putting our library in the best possible condition under very trying circumstances.

COMMITTEES: The Institute continues to enlist the advice and enthusiastic support of many men and women not only in scientific pursuits but also in a wide variety of callings. Inevitably more work and responsibility devolves on the officers and other members of the Council. I wish to pay special tribute to, and on behalf of the members to thank, all those who this year have contributed to the welfare and advancement of the Institute.

The entertainment of the distinguished scientists who lecture before the Institute is a most important duty in view of the fact that we pay no honorarium to our lecturers. This year the entertainment offered our lecturers was arranged by a committee of which Professor L. J. Rogers, our Second Vice-President, was Chairman. Inevitably in matters of entertainment wives come in for a good share of the responsibility. Mrs. Rogers has generously shared the responsibility of Professor Rogers for arranging for this year's entertainment and also she must share the credit and thanks for the successful outcome of the work of the entertainment committee.

The membership committee under the able and energetic chairmanship of Professor J. Ellis Thomson has been unusually successful in obtaining what is believed to be a record number of new members for one year, namely 284.

The Institute is indebted to a number of commercial and industrial organizations for taking out membership in the Institute in the name of a number of their employees.

Unfortunately we have lost many members through death and resignation, but our total membership now stands at 1,378, which is believed to be a record in the history of the Institute. The credit for this eminently satisfactory condition of our membership is due to the work of the membership committee.

We record with regret the passing of twenty-one of our members including Prof. D. R. Keys, a former librarian, and Father A. G. Morice, an Honorary Member of the Institute.

MEMBERSHIP AS AT APRIL 1, 1940.

Honorary	2
Life	47
Ordinary	1002
Associate	171
In Arrears	156
	1378

Our finances are under the capable supervision of our Honorary Treasurer, Mr. George C. Gale. Detailed statements of revenues and expenditures will be furnished any member on request.

We are again under obligation to Mr. C. Watson Sime and H. Frank Vigeon for their having audited the Institute's books.

Arrangements for the Conversazione were made by a committee of which Mr. George C. Gale was Chairman. That committee was ably assisted by three ladies, Mrs. Gale, Mrs. Starr and Mrs. Dymond.

HONORARY MEMBERSHIP: A committee under the chairmanship of Professor C. R. Young went carefully into the question of Honorary Membership in the Institute, with the result that four members who have rendered outstanding service to science and to the Institute were elected to Honorary membership.

GENERAL POLICY: The General Policy Committee under Mr. Wills Maclachlan has considered what the policy of the Institute should be in view of the war. One of the decisions resulting from the deliberations of this Committee is that next session a number of lectures dealing with different phases of our military effort will be arranged. Another result of the work of this Committee is that a special Sub-committee under Colonel H. J. Lamb is bringing together literature for donation to the libraries in the Training Schools of the Royal Canadian Air Force. So far 155 volumes have been donated for this purpose; of these, 104 volumes have already been turned over to the Air Force.

RETIRING MEMBERS OF COUNCIL: A few years ago the Institute adopted a rotary system of election to Council. Three new members are elected each year and three retire each year; new members of Council remaining for a period of four years. This works to the advantage of the Institute in enlisting the interest of a much larger number of members than was formerly the case. Through the working of this rotary system we, this year, lose Dr. C. E. Cooper Cole, Mr. H. M. Forbes and Professor W. H. Martin from the Council. Mr. J. H. Brace during the past year moved to Montreal and he has asked that his resignation be accepted. Also, every time we get a new President we lose a former President, since only three

past Presidents remain on the Council at once. This year we lose Sir Robert Falconer. All of these gentlemen have rendered faithful and valuable service to the Royal Canadian Institute and on your behalf I extend to them our best thanks for their work on behalf of the Institute during the years they have served on its Council.

THE MUSEUM AND THE UNIVERSITY: The Institute is greatly indebted to the Trustees of the Royal Ontario Museum for the privilege of holding its Annual Conversazione in the Museum, and the Board of Governors of the University of Toronto for allowing us the use of Convocation Hall for our Saturday evening lectures. The co-operation of the University in all matters connected with the work of the Institute contributes materially to its success.

Finally I have to thank Mr. Bruce Murray, our executive secretary, for the splendid service which he has rendered to the Institute during the term of my Presidency. There are some labours and responsibilities involved in this office which no one else can assume but so far as it is possible Mr. Murray has smoothed the way of the president in a manner which only one who has occupied this position can appreciate. My personal thanks are extended to him for his very generous assistance throughout the year.

I am sure also that every member of the Institute who has had occasion to consult our office has received the most willing and courteous service.

Not least important of Mr. Murray's contributions to the Institute is the thorough and generous way in which he looks after our lecturers while they are in Toronto. Many of them become his personal friends. This service alone contributes considerably to the reputation which the Institute enjoys for the hospitality extended to lecturers. On your behalf as well as my own, I extend warmest thanks to Mr. Murray.

J. R. DYMOND,
President.

The Saturday Evening Lectures

One of the objects of the Royal Canadian Institute is to further a popular interest in research. Since the results of research are so far-reaching in their effect upon the life of every member of the community, it is necessary to create an intelligent public who will be able to follow the work and achievements of those who are engaged in it.

What has been done in the past is illustrated by such important accomplishments as the invention of the telephone and the radio, the discovery of radium, the improvements of the telescope; also by the immense access of knowledge as to the structure of matter, whether in the atom or the universe, the manifold phases of life on the earth, and the exploration of the world.

The lectures of the Institute are the medium whereby such work is explained to the public. On Saturday evenings during the season, popular lectures of a scientific nature are given by men outstanding in their own field.

"The Study of Animal Life in Canada"

J. R. DYMOND, M.A., F.R.S.C.

Director of the Royal Ontario Museum of Zoology.

November 4th, 1939.

In the years since the Canadian Institute was founded in 1849 conditions under which men live have been changed more than during all previous history. Most of these changes have been brought about through the application of science.

Methods of transportation have been changed from travel on foot or by horse to travel by steamship and railway, motor car and airplane; illumination by candle has been replaced, first by the coal oil lamp and later by the electric light; intercommunication has been speeded by the invention of the telegraph, telephone and radio and diseases such as cholera malaria, typhoid fever, smallpox and diphtheria responsible for frightful epidemics less than a century ago have been largely brought under control. Such changes together with similar advances in other fields have completely transformed the world in which we live.

That changes in the political realm have not kept pace with those in fields in which the methods of science have operated is illustrated by a quotation from Robinson's "History of Western Europe."

> "The Czechs determined to offset the movement toward German consolidation by a Pan-Slavic Congress, which should bring together the various Slavic peoples comprised in the Austrian empire. To this assembly, which met in Prague in June, 1848, came delegates from the Czechs, Moravians, Ruthenians, and Poles in the north, and Servians and Croatians in the south. Its deliberations were interrupted by an insurrection that broke out among the people of Prague and gave the commander of the Austrian forces a sufficient excuse for intervening. He established a military government, and the prospect of independence for Bohemia vanished. This was Austria's first real victory."

This sounds very much like a report of troubles leading to the present war. Contrast the marvellous development in the field of applied science with the failure to solve some of the problems in other fields of human interest.

It is probably true that in the changes produced by the applications of science, advances due to physics and chemistry have been more spectacular than those based on the study of animal life. It was the purpose of this lecture to outline some of the advances due to the study of animal life in Canada.

It was our fisheries and fur that first interested Europeans in Canada, and rivalry for the rich fur trade of Canada was the cause of the early struggles between the French and English in this country. The services of

science have been enlisted on behalf of the fishing industry since 1899 when the first Canadian marine biological station was established at St. Andrews, New Brunswick. Today the Fisheries Research Board of Canada has seven stations on the Atlantic and Pacific coasts and employs approximately thirty-five scientists to investigate a wide variety of subjects connected with the fisheries. In addition Canada and the United States support two international fisheries commissions,—one to control the halibut fisheries of the North Pacific and the other the salmon fisheries of the Fraser river. Freshwater fisheries are also being studied. The most important of these researches are being carried on by the Fisheries Research Laboratory of the Department of Biology, University of Toronto under Prof. Harkness.

As an example of the results accruing from fisheries research, the results of the halibut studies are cited. Formerly the halibut fisheries of the North Atlantic and North Pacific oceans were worth fourteen or fifteen million dollars a year. Over half of this was produced in the North Pacific but over-fishing seriously reduced the returns to the fishermen. For a time the total yield was kept up by going farther and farther afield for the fish but when the last fishing grounds were reached and depleted, investigations were begun under the auspices of the Halibut Commission. Under this Commission a thorough scientific study of the halibut and of the conditions under which it lives in the North Pacific was made. It was found for instance that where fishermen once caught three hundred pounds of halibut on a given number of hooks in a certain time they were now catching only thirty-five pounds on the southern fishing grounds and sixty-five in the north. Halibut spawn for the first time when twelve years old. Fishing was so intense on many banks that few fish ever got big enough to spawn. Population studies indicated that by reducing the fishing intensity by 14% the number of spawners would be doubled and if the fishing intensity were halved, the increase in spawning fish would be ten fold. As a result of the regulations put into effect, the catch on a unit of gear in a unit of time has already been increased in the south from thirty-five to sixty pounds and in the north from sixty-five to ninety pounds. This improvement has continued until now the fishermen are catching more halibut in a shorter time and the population of fish is increasing. This sounds like magic, but it isn't. The results are based on sound principles founded on facts obtained by the method of science.

The work of the halibut commission and of its scientific staff is a fine example of applied zoology and a demonstration of what science can do for any industry, if properly supported.

Studies by similar methods and with the same objects in view are under way on a wide variety of fish including Atlantic and Pacific salmons, herring, cod, haddock, pilchard, as well as on lobsters, oysters and clams. Researches are also improving the methods of freezing, smoking, canning and drying fish. Oils derived from fish are receiving thorough study. Vitamins are being searched for in the bodies, livers and other parts of a wide variety of Canadian fish.

Freshwater fish including speckled trout and lake trout, whitefish and bass are also being studied with the purpose of discovering means for exploiting our freshwater fisheries on a sustained yield basis.

There are probably more than a million different kinds of animals on the earth. Many of these make it easier for man to get a living and be happy here but a large proportion of that million are serious competitors or enemies of ours and make it harder for us to maintain ourselves or cause us grief and suffering. The insects, of which there are more than of all other kinds of animals together, are usually credited with being man's chief competitors for the food which the earth yields. The Entomological Service, Ottawa, estimates that the depredations of insects cost Canada more than $100,000,000 annually.

The live stock industry of Canada is worth many millions of dollars annually. As an example of the application of zoology to the welfare of the live stock industry reference is made to the importance of the study of the parasites of sheep. Lambs in Ontario have been shown to be infested by nineteen kinds of parasitic worms. The life histories of none of these are well enough known to enable them to be adequately controlled. Losses due to infection by these worms cause serious loss in sheep raising.

A start has been made toward a study of Canadian wildlife problems but only the surface has been scratched. The fur trade is producing only a fraction of what is possible. Many areas have only a few beaver colonies where it is possible to support dozens. Over most of Canada this valuable animal has been trapped almost to extinction. Our wildlife offers an immense field for research. The proper management of our wildlife resources is especially important in Canada because such a large area of the country is unfitted for agriculture but well suited to grow trees and to serve as a home for game and fur-bearing animals.

Fifty-six per cent. of the area of Canada is occupied by land of no value for forestry or agriculture and another thirteen percent. is unproductive forest land. Apart from its mineral wealth almost the sole use of this sixty-nine percent. of Canada's area is in the production of game and fur-bearing animals and fish. Researches which will yield information as to the best method of handling our wildlife and fisheries resources are therefore fundamental to Canadian welfare.

The contrast between the comparative lack of progress in some fields of human interest and the marvellous changes produced by science in other directions has been mentioned. Admittedly man is a more difficult animal to control than are fish or insects but few human problems are beyond the reach of the scientific method. Man and his behaviour is just as capable of being understood as is the behaviour of any other animal. If the scientific method is brought to bear in attacking problems of human behaviour, I venture to prophesy that during the next hundred years greater advances will be made in this field than have been made in many previous centuries.

"How Civilizations Grow"

RALPH LINTON, PhD.

Professor of Anthropology, Columbia University, New York.

November 11th, 1939.

Civilizations grow in periods of rapid, specialized growth which alternate with eras of retrenchment and reorganization. These periods of rapid growth stem from the inventive ingenuity of man. The inventive faculty flourishes in times of security and stability. Necessity is not the mother of invention. Many men invent from curiosity, for their own amusement, or in order to gain admiration and prestige. Many inventions are still-born because they do not fit into the culture pattern of the period. People accept the discomforts incidental to their civilization as a matter of course; they do not demand that their lot be ameliorated.

Civilizations also grow by borrowing ideas from other cultures. Actually every society of which we have record owes more to borrowing than to inventions of its own members.

The initial acceptance of an invention by a civilization is only the first step. It has then to be integrated. It must be woven into the warp and woof of life if it is to endure. Many inventions are only fads. Others, like the automobile, may change the stream of civilization.

Fixation on gadgets and technology are characteristic of our American life today, but we have let most of the rest of our culture fall into neglect. People generally take to those things which are of questionable value, rather than those with greater productive potentialities. The cigarette lighter is less reliable than a box of matches, but people overlook this because of the novelty of the device.

A culture that makes tremendous advances in one direction without developing in others is bound to collapse. The last century's unparalleled interest in new mechanical contrivances may herald an age enamoured of keeping social arrangements as they are. "A new car by all means, a new hat certainly—but no new ideas!" Unless the gap between the development of the social and economic system and that of scientific progress can be closed, the civilization of today is due for rapid retrenchment.

There have been three great turning points in human history. The first took place in the dim past when man first learned to make fire and use tools. The second took place 8000 years ago when man learned how to raise food by cultivation. That raised the population ceiling, made possible the development of city life, nurtured the development of the wheel, the loom, and the plow. Civilization continued on its placid way until the Scientific Age struck with full force about the year 1800.

In some respects civilization has changed more extensively during the last 150 years than in the 4000 years before 1800 A.D. If George Wash-

ington could visit the court of the famous Hammurabi, King of Babylon, about 2,200 B.C., he would have felt more at home, or at least would have seen fewer things that he could not understand, than if he had paid a visit to modern New York.

"Building Downwards"

R. F. LEGGET, M.Eng. (Liverpool) Assoc. M.Inst. C.E.
Assistant Professor of Civil Engineering, University of Toronto.

November 18th, 1939.

Civil engineering was originally that branch of engineering which did not concern itself with military or naval projects; gradually the term has been restricted during the last hundred years so that today such specialist branches of engineering as mechanical, electrical and mining stand apart. The civil engineer seeks to dominate and exploit nature for the use and convenience of his fellow men; he has therefore much to do with the surface of the earth, for he must consider it in all his foundation work and in the driving of tunnels and other underground excavations.

Foundation engineering seems to have an attraction for the layman; the lecture included descriptions of unusual foundation work carried on remote from cities, and mention was made of exceptional tunnelling projects including the proposed Channel Tunnel between England and France which is held to be quite practicable as the result of long studies made along the proposed route.

River and flood control is another important part of civil engineering work; it is closely associated with soil erosion, a phenomenon of growing seriousness in many parts of the world, brought about by man's ruthless attack on forests and topsoil. Rigid steps must be taken to control it. In the United States good progress along this line has already been made. There is need for corresponding progress in Canada.

Here in Ontario there are cases of soil erosion which, in nature although not in extent, are as bad as any elsewhere—some within twenty five miles of Toronto. Something must therefore be done about this problem even in our own province, and done quickly before it is too late. Nothing can be done without public interest and support.

Shakespeare supplied an answer to the obvious question about soil erosion when he says, in "Much Ado about Nothing":—

> ". . . for it so falls out
> That what we have we prize not to the worth
> Whiles we enjoy it; but being lacked and lost
> Why, then we rack the value; then we find
> The virtue that possession would not show us
> Whiles it was ours."

"Explorations with High Pressure"

R. B. DOW, PH.D.

Assistant Professor of Physics and Chemistry, Pennsylvania State College.

November 25th, 1939.

Although as far back as the 17th century scientists sought to work with high pressures, it was only in the early years of the present century that pressures of the order of 10,000 atmospheres were achieved. Pressures as high as 50,000 atmospheres—i.e., 750,000 pounds per square inch—have been obtained today.

The early methods of producing hydrostatic pressure were by compressing lead spheres filled with liquid, by sinking chambers (cannon) under water, or by forcing pistons into chambers by means of screws of high mechanical advantage but of low efficiency.

Modern methods are principally a refinement of the old principle of the hydraulic jack. Special packing designed to prevent leakage around the pistons must be used. When pressures of around 50,000 atmospheres are desired, the test chamber is forced into a massive steel block. The pressure within the test chamber is measured by observing the electrical resistance of manganin wire in the pressure chamber. This method is more accurate than trying to estimate the pressure by measuring the diameters of the pistons.

The behaviour of metal vessels that are subjected to considerable internal pressure has been the object of much investigation. The metal within the vessel flows, a phenomenon which profoundly influences the strength of the vessel. The vessels will expand considerably before breaking down.

The plastic flow of metal and the subsequent cold—working under high pressure have been used to strengthen big guns. This process put the metal adjacent to the bore under an initial compression and the exterior metal under an initial tension; the effect on the metal at the bore is similar to that produced by shrinking an exterior cylinder on the gun.

When subjected to very high pressure, wood changes to a translucent horn-like substance, PbO decomposes to metallic Pb, and red phosphorus changes to the dense black modification.

VISCOSITY OF LIQUIDS UNDER PRESSURE

Viscosity is one of the fundamental physical properties of a fluid. For a liquid it is greatly intensified under pressure, a 1000-fold increase for a pressure increase of a few thousand atmospheres being quite common. Very roughly, it may be said that the greater degree of interlocking of molecules considered responsible for the high viscosity at high pressure depends on the molecular weight as well as the structure of the molecule.

Viscosity of lubricating oils is particularly important. Oils rich in paraffinic molecules show relatively less increase in viscosity under pressure. It has been shown that oils from a Pennsylvania crude, rich in paraffinic content, have lower pressure coefficients than oils refined from crudes from other parts of the American continent. These latter oils are invariably rich in napthenic and aromatic constituents. At the present time arrangements have been made to secure oils especially rich in aromatic compounds. Such oils come from Russia, Burmah, Roumania, etc.

GERMINATION OF SEEDS TREATED BY HIGH PRESSURE

Work was undertaken to determine the possible effect of pressure on the germination of various seeds. Altogether 80,000 seeds were tested. The effect of pressure in speeding up the germination of yellow-wood seeds is striking. The effect on coffee beans is just the opposite; all the seeds were killed by exposure to the lowest pressure. The effect of pressure may be physical, similar to scarification. However, after pressure treatment, an increase in lipase activity was noted in the castor oil bean. This suggests that the effects of pressure are not wholly physical.

BIOCHEMICAL EFFECTS AT HIGH PRESSURES

At sufficiently high pressures blood was coagulated to a reddish-brown rubbery mass that did not seem to decay when left exposed in the room for several days. After exposing a sample of blood to a pressure of 3500 atmospheres for three hours the following blood counts were observed: red cells (normally 7,300,000)—800,000; white cells (normally 6700)—800.

Since blood is a complex substance, experiments have been conducted on simple proteins, e.g., pepsin and rennin. The results indicate that denaturation is responsible for loss of activity under pressure.

The effect of Pressure treatment on 24 and 48 hr. growth bacteria was also investigated, and it was shown that a serious increase in the mortality of the bacteria had taken place. Although it could not be definitely said that pressure changed the chemical and biological characteristics of the bacteria, a definite answer is expected in the near future.

"The Role and Accomplishments of Modern Sanitation"

A. E. BERRY, M.A.Sc., C.E., Ph.D.

Director, Division of Sanitary Engineering, Department of Health, Provincial Government of Ontario.

December 2nd, 1939.

The problems of sanitation are as old as civilization. As community life became more complex, in the absence of any well-founded effort towards sanitation, great plagues swept the earth and ravaged the cities. Always, in the past, civilization has reached its peak when sanitation and social welfare have developed to the highest degree.

Sanitation is closely connected with public health measures. Life and health are dependent in very large measure upon understanding and practising the laws of sanitary science: i.e., the science which deals with the diseases that affect human beings, diseases which may be spread by food supplies, water supplies, the improper disposal of sewage and wastes, and by other environmental conditions.

Although practice has always lagged behind research, there has been a steady advance in the understanding of sanitary science. For instance, in London between 1660 and 1680, the death rate was 80 per 1000. By 1850 it was down to 25 per 1000. Today, in Ontario, it is less than 10 per 1000. However, until the middle of the 19th century, when it was shown that bacteria were the cause of disease, public health officials were to all intents and purposes groping in the dark.

A system founded on enlightened principles was introduced in Britain in 1875, and a law modelled on that of Britain was introduced in Ontario soon after. In Ontario the activities of the Provincial Department of Health has a record of continuous development in line with modern needs. The Provincial Department has several Divisions. There is the laboratory division, which gives service to physicians, and through which milk and water supplies, and food products are reported on. Another division deals with maternal and child welfare. There is a division devoted to industrial hygiene, and another devoted to the control of tuberculosis, social diseases, communicable diseases, etc. Public health education is dealt with through another division.

The Division of Sanitary Engineering is one of these branches. It is concerned with water supply, sewage disposal, stream pollution, milk and food control, disposal of various wastes, and recreational sanitation. All in all it covers quite a large field.

The Romans, with their genius for dominating and exploiting nature, constructed formidable aqueducts for bringing water from the mountains to their cities. Today, in Toronto, for example, it is taken directly from the lake, while in Calgary, a dam is used to store river water. The first methods for purification were based on filtration through sand and gravel.

With the installation of chlorination equipment to purify the water, there has been a sharp and persistent decline in typhoid fever. Exception is sometimes taken to the "taste" of chlorine in water. This taste is due to impurities, not to chlorine alone; indeed by increasing the dose of chlorine it is sometimes possible to reduce the taste, because chlorine is a good oxidizing agent and destroys some of the taste-producing substances.

Although a definite step forward has been taken in this province by passing legislation which makes the pasteurization of milk compulsory, there are still a few who insist that such a measure is an encroachment on their personal liberties. It is sometimes necessary in public health to cause inconvenience to an individual in order to protect the community. Many persons suffering from physical deformities today can attribute them to polluted milk. Pasteurization of milk is necessary in order to prevent bovine tuberculosis, and typhoid, paratyphoid and undulant fevers.

A good milk supply begins with a clean herd of healthy cows free from disease and housed in clean stables. The milk is pasteurized by heating to 143° F. for 30 minutes. The milk is then bottled and capped mechanically with scrupulously clean equipment.

The education of the public, and particularly, of public officials, has been of paramount importance in public health. Voters will have the final word as to the method of handling these problems which affect the welfare of every individual. A serious responsibility therefore rests on all concerned to see that the public is as fully informed as possible.

"Climates of Other Worlds"

FRANK S. HOGG, Ph.D.

Assistant Professor of Astronomy, David Dunlap Observatory, University of Toronto.

December 9th, 1939.

Most of the known astronomical objects are not "worlds," they are stars—globes of intensely hot gas, like the sun. Only the planets have physical characteristics at all comparable to those found on the earth.

Astronomers do not look forward to exploring these other planets in person. Neither have they telescopes powerful enough to detect possible life on these planets. However, it is possible to examine the physical and chemical phenomena of these other worlds to determine their suitability for life as we know it here.

The planets, nine in all, revolve around the sun. They differ radically in temperature, pressure and composition, according to their size and their distance from the sun. The inner planets have a greater density and also rotate more slowly on their axes.

Three methods are employed to obtain information about the heavenly bodies. Huge telescopes are used to pry out surface detail. Spectroscopes are used to analyze the light they emit for chemical constituents. Finally, radiometers are used to measure the intensity of the light they emit so that the heat of the object may be calculated.

The physical characteristics of the planets (in their order from the sun) may be summarized as follows:—

Mercury, the smallest of the planets and the one nearest the sun, has no atmosphere; and the force of gravity is so small that any atom of the atmosphere would escape into space. It is hot enough to melt lead on the side which at certain times faces the sun; on the other, it approaches Absolute Zero. Surface detail is obscured because it must be examined close to the sun.

Venus is about the same size as the earth. Dense masses of cloud effectually hide surface detail. These clouds prove the presence of an atmosphere. Great quantities of carbon dioxide have been found in the atmosphere. Average temperature is around zero, varies between 100° above on the sunny side and 100° below on the dark side.

The Earth is next in line from the sun.

Mars is the fourth planet. It is about one-half the size of the earth. It has a reddish appearance. There is a large polar cap which melts during the summer season. The temperature varies from below room temperature to about 100° below. There might be animal or vegetable life on Mars but indications are that Mars could not have more than one-tenth of one per cent. of the amount of oxygen on the earth, or more than one per cent. as much water vapour.

Jupiter, the largest of the planets, with a diameter eleven times that of the earth, is gifted with an elaborate cloud system, obscuring surface detail; and eleven moons. The atmosphere is composed of Ammonia and Marsh Gas. Temperature—around two hundred below.

Saturn, familiar to all as the planet with the ring, is nine times the size of the earth. Temperature: two hundred below. Atmosphere: Ammonia and Marsh Gas.

Uranus: four times the size of the earth. Atmosphere: solely Marsh Gas. Temperature: close to three hundred below.

Neptune is four times the size of the earth. Covered with dense clouds, composed chiefly of intensely cold Marsh Gas.

Pluto is the baby of the planets. Smallest of the planets, last to be discovered (in 1930). It is 3,666,000,000 miles away from the sun. Nothing can be seen of surface detail.

Thus, according to our present fairly definite knowledge, our earth possesses the only climate to which human beings would find themselves suited.

"Romance of Canadian Radium"

JOHN D. LEITCH, PH.D.

Director of Research, Eldorado Gold Mines.

December 16th, 1939.

Canada's one and only radium mine is located on the shores of Great Bear Lake, about 1000 miles north of the City of Edmonton. The district was first explored in 1789 by Alexander McKenzie who made some very good maps of the region.

Pitchblende, an ore containing uranium, silver, cobalt and radium, was discovered there in 1930 by Gilbert Labine, President of Eldorado Gold Mines. Development followed in 1931. Radium City on the shore of Great Bear Lake, near the Arctic circle, is now a thriving community. Since navigation via the Mackenzie River system is open for only six weeks of the year, the time available for shipping out ore is greatly limited. Airplanes proved very useful in the early days in transporting ore and supplies before the work was fully organized. They are still used for transportation of workers and officers of the company.

The ore is taken to Port Hope for treatment, a distance of fully 5,000 miles. Since it requires eight tons of chemicals to treat one ton of ore, it is safer and cheaper to ship the ores out than the chemicals in.

A battery of six diesel engines produces 1150 horsepower at Radium City. Oil is brought from the wells at Fort Norman, just 150 miles away, and can be used just as it comes from the well.

At Port Hope the problem is how to recover about one-three-hundredth of an ounce of radium from a ton of ore. This is accomplished by a long tedious chemical reduction process followed by fractional crystallization which separates radium from parium. The whole process takes about three months. A little tube of radium bromide results. It is sent to the National Research Council at Ottawa where the radium content is certified by measuring the intensity of the rays which are emitted by the radium.

The importance of radium lies in its unusual property of emitting radiation called "gamma rays." These rays are similar to X-rays but have a shorter wave length, and consequently are more penetrating. When radium is used in the treatment of cancer, it is these rays which are responsible for the therapeutic effect. In practice the radium is enclosed in thin-walled platinum needles and tubes through which the gamma rays pass easily. The needles are used interstitially while the tubes are applied to surface lesions or intra-cavitarily. When radium is used in large quantities such as two or more grams the therapeutic method is referred to as telecurietherapy and the instrument which is a large lead-filled vessel is called a "pack" or "bomb."

Radium emanation is a gas which is the first product of disintegration of radium. The radioactive properties of the gas are much the same as those of radium but its half life is only 3.85 days while that of radium is 1690 years. The Ontario Department of Health has a pumping machine for the extraction of radium emanation from an aqueous solution of 300 mg of radium bromide. The gas is sealed in small gold tubes called "seeds" and shipped by express to private doctors and Government Cancer Clinics throughout the entire Province.

The Ontario Department of Health has some seven or eight grams of radium contained in hundreds of platinum needles and tubes. It cost $8,000 a year to insure these needles against loss. The tiny needles may slip into discarded bandages and finally finish up in the city dump. That has happened at least five times in the past four years. A machine sensitive to gamma rays called a Geiger Mueller radium detector was built at a cost of about 200 dollars. The radium was recovered in every instance and insurance was allowed to lapse with considerable saving to the Province.

"Archeological Explorations in North America"

P. NASH, PH.D.

Department of Anthropology, U. of T. and Royal Ontario Museum of Archaeology.

January 6th, 1940.

The Archeologist should recognize his position as historian. He should give time-sequence to the life of a people. He has been able to do this because new methods of study have given us more information about the early inhabitants of this continent than it once seemed possible to procure.

Tree-ring datings are a basic device for archeological study from a historical point of view. This device was developed to investigate the Indian culture of the south-western United States. While the age of a tree can be calculated quite simply by counting the rings of yearly growth, the rings vary in width because in good years more growth takes place than in bad. By carefully dovetailing charts made by examining these rings of annual growth, a master chart has been prepared which permits identification as to age of any piece of wood from the area as far back as five hundred A.D.

A master chart has been prepared for the Mississippi Valley region, and for the New England States. There is no reason why such a chart could not be prepared for the St. Lawrence Valley area.

It is now well established that people inhabited and cultures existed in the New England States and very probably this part of Ontario about the time of the birth of Christ.

Four cultural types of civilization have been established in the Northeast Woodlands area, which comprises the St. Lawrence Valley, Ontario and Manitoba, and which runs from the southwest portion of Hudson Bay down almost to Ohio.

The first of these was the Archaic. It is believed to have existed about the time of the birth of Christ, when the New England States were inhabited by a nomadic, non-agricultural, non-pottery making people. It is the oldest culture which is definitely known to have existed in this area.

The second is the Woodlands culture. During this period a culture of a semi-nomadic type existed and pottery making was begun.

Then came the Iroquoian. In its later phases it is linked with the historic period. During the Iroquoian period there were large settlements, usually on top of a hill. The pottery was excellent and they were skilled workers both in bone and stone.

Finally there is the modern period, which came into being about 1600 A.D. Copper kettles and finer implements were produced.

Excavations conducted by the Royal Ontario Museum on the Indian village site near Aylmer, Ontario, indicate that an agricultural people existed who lived in communal structures, who hunted and fished, and who had enclosures to keep the deer and other animals out of their corn and beans. The culture appears to be on the boundary between the Woodlands and the Iroquoian periods.

"The Utilization of Farm and Forest Products"

HAROLD HIBBERT, PhD., D.Sc., LL.D., F.R.S.C.

Professor of Industrial and Cellulose Chemistry, The Pulp and Paper Research Institute, McGill University, Montreal, Canada.

January 13th, 1940.

Are we on the brink of a new era in Canada when large portions of this country's vast agricultural and forest domain will be devoted to supplying materials for industry as well as for food? The answer will depend in large measure upon the scientist, but there are already indications that this is within the realm of possibility.

At present, in her pulp operations, Canada sends 900,000 tons of waste materials floating down the river each year. In the not too distant future this waste may be reclaimed and turned into various products, much as the once-despised by-product, coal tar, is now used.

One of the most important materials contained in this waste is a substance known as lignin. From lignin certain plastics are already being

made. Some day Canada's forest resources may be turned toward the supply of basic materials for a plastic age, in which even automobiles and airplanes may be manufactured—with the exception of their motors and other mechanical parts—from this substance. Because Canada, in common with many other countries, is years behind in construction, the surplus of steel created by this revolution could be used up in other channels.

And what of Canada's agricultural destiny, because Canada has been for years the greatest wheat producing country in the world? When a demand for her wheat has fallen off seriously she has suffered widespread depression in the prairie provinces. If a large portion of Canada's wheat lands were planted with soya beans, income from the country's crops might be stabilized to a great extent.

During the last seven or eight years the soya bean has developed in the United States from a practically negligible crop to one worth about $70,000,000 last year. And one of the principle causes for the Japanese invasion of China was the desire on the part of Japan to gain control of the soya beans industry in Manchuria.

The value of the soya bean lies in the fact that many important by-products can be manufactured from its constituents. It is forty per cent. protein, twenty per cent. fats and oils, five per cent sugar, contains important sterols, and the rest is water. Henry Ford spent three million dollars developing the industry in the United States because he feels that oil obtained from the soya bean will supplant many of the costly products now used in building an automobile.

Soya beans form the basis for a good cattle feed. Five per cent. cellulose may be obtained from it. Soya bean flour, with a high protein content, has been developed. Oils valuable to the paint and varnish industry can be obtained. The sterols found in the soya bean can be converted into the new sex hormones which have so recently been discovered. The protein can be converted into bakelite. Altogether the soya bean is a most versatile crop.

The scientist believes in the pursuit of truth at all costs, and he has an infinite faith in his ability to follow through that which is indicated by his researches and his findings. When this war is over, Canada will be industrialized as never before. Then, if ever, the scientist will be doubly needed to point out the way.

"Exploring The Ocean Floor"

LIEUTENANT PAUL A. SMITH, B.S.E., F.G.S.A., A.S.C.E.

Hydrographic and Geodetic Survey, Washington, D.C.

January 20th, 1940.

With the expansion of commerce which followed on the development of steamship navigation, more thorough and accurate charts were required. The shores of the ocean are continually changing; erosion, wind and tide have their effect. Beneath the sea similar changes are taking place, some caused by currents, some by volcanic action, and so on.

During the past ten years, by using new, indirect methods of sounding, more has been discovered about the ocean floor than during all previous history. The new method is called echo sounding. Sound is projected to the bottom of the sea; it strikes the bottom and returns. The time it takes to make the round trip can be measured and the speed it travels is known. So the depth can be calculated. All readings and calculations are now automatic. The depth can be read to within a foot up to fifty fathoms —three hundred feet. A continuous graph showing the depth is produced automatically. For locating the position of the survey ship in offshore areas when coastal charts are being prepared, complicated electrical and acoustical equipment is used, which bears up marvellously well in the case of sono-radio buoys which are exposed to all the inclemencies of the weather.

Beneath the sea lie mountains, valleys and plains. These are of interest to the geologist as well as the navigator. One of the most impressive of submarine phenomena is the formation found off the Atlantic coast of the United States. The Atlantic continental shelf which is from fifty to one hundred miles wide is 600 feet below the surface of the water at the seaward edge. The shelf is so flat that an automobile could probably be driven anywhere upon it if it were above water. But when one reaches the edge, it drops away eight to ten thousand feet in about twenty miles. Huge canyons are found in this continental slope, some of them are more than three thousand feet deep and five miles wide, and the beds of the canyons often slope more than 150 feet to the mile. The slope of the Colorado river in the Royal Gorge is only 12 feet to the mile, so that if water were running down these huge undersea canyons they would be mighty streams indeed.

By means of dredges, chunks of rock may be obtained from the ocean floor. The rock is studied by geologists to determine the age of the formations in which the canyons are cut. Rock from these giant canyons off the Atlantic coast show it to be of Tertiary or Cretaceous age, geologically speaking, which means less than about 50 or 60 million years. The canyons, of course, were cut in the rock after the sediments were deposited.

The origin of the canyons, however, is still a puzzle to science. Were they formed at a time when the whole formation was above water, and great rivers surged down towards the sea; or, when the ice covered the face of the continent, did it stir up silt-laden water that, being denser than normal sea water, ran down over the slope and eroded the slope under sea water?

A number of other hypotheses have been advanced to explain their origin, all of which encounter some serious objections in the face of existing geological theory, and there is no satisfactory answer to that question at this time. It is,. however, interesting to note that if the ocean were to recede 12,000 feet, a chain of dry land connecting Africa and America would be uncovered, and that would give biologists the connecting link they need to relate the fauna of South America with that of Africa. Under such a postulate the post-continent of Atlantis may have been no idle dream.

The primary purpose of the surveys, however, which have caused scientists to speculate upon these striking features of the sea floor is to serve navigation. The submarine valleys and mountains so mapped afford a positive means of position finding for navigators equipped with depth recorders and accurate charts of the sea floor.

"The Petroleum Industry Stream-lined"

R. K. STRATFORD, B.S.A., M.Sc., D.Sc.

Chief Research Chemist, Imperial Oil Ltd., Sarnia, Ontario.

January 27th, 1940.

In the last two decades great developments have occurred in the production, manufacture and distribution of petroleum. Possibly the most notable progress has been made in its manufacture. The refining of petroleum has been completely revolutionized. The changes can be traced to a few fundamental discoveries, the applications of which may be summarized under the following five headings:—

First—Continuous Operation. A few years ago a still was utilized; the fractions were taken off one after another. When a number of stills were arranged in series it was found possible to charge the unit continuously, taking off the desired fraction from each still. This principle was subsequently applied to practically all other refinery operations.

Second—The Fractionating Tower and heating coil. The fractionating tower was a device borrowed from the alcohol industry. It increased the yield and the quality. Then the shell still was superseded by the heating coil. A consolidation of equipment and a simplification of operation resulted that had not been previously considered possible.

Third—The cracking of heavy oils to produce gasoline. Introduced in conjunction with the use of a fractionating tower and heating coil, a very high efficiency resulted, as well as greatly increased yields of gasoline.

Fourth—The use of Solvents. About twenty years ago a solvent was first used to remove undesirable materials from petroleum fractions. For instance, phenol and propane are used to remove asphaltic or aromatic constituents from lubricating oil fractions. Wax may be removed from the same fractions by solvents such as propane at low temperatures.

Fifth—Centralized and Automatic Control. Operations are now controlled from a central room. Many operations previously separate have thus been coordinated.

These five basic discoveries have been modified to fit almost every operation in the manufacture of petroleum products. Combination units for distilling and cracking have been developed. A combination unit is now in operation with a capacity of over 35,000 barrels a day, and solvent extraction plants of 8,000 barrels a day are common. This progress has been made possible because the gap between pure scientific knowledge and its practical application has been bridged.

One of the most remarkable features of this "stream-lined" industry is the manner in which clumsy and inefficient equipment has been transformed into highly efficient and beautifully designed units. Here is the synthesis between art and science which the creative mind has been fervently seeking.

"Seventy Years A Naturalist"

W. E. SAUNDERS, LL.D., London, Ontario.

President of the Federation of Ontario Naturalists.

February 3rd, 1940.

One of the great ornithological mysteries of this continent is the sudden and calamitous disappearance of the passenger pigeon. In 1869, as an eight year old boy on his father's farm, Dr. Saunders interest in ornithology (he still claims he is an ornithologist, not a naturalist) was aroused by the huge flocks of birds which descended on the countryside and did much damage to the farm.

The last big nesting place Dr. Saunders heard of was in Michigan, in the eighties. It was eight miles long and three miles wide, in a forest, and every tree was loaded with nests. About forty thousand birds were shipped out of the district daily by hunters. During this period (1880-1890) the birds dwindled rapidly. The last specimen died in 1914 in the Cincinnati Zoo, at the age of 25 years.

Dr. Saunders suggested the pigeons disappeared utterly because when the numbers dwindled, those that remained, motivated by their gregarious nature, roamed the countryside seeking the big nesting place, and thus neglected to breed. Total extinction followed.

He explained that an ornithologist works with his ears, identifying birds more often by sound than by sight. Gramophone recordings made at Cornell University showed that many tones in a bird's voice vibrate at from eight to ten thousand cycles per second. The highest note on the piano vibrates at about 4,000 cycles.

Dr. Saunders praised the Ontario Government for protecting the eagle and the osprey. He expressed hope that it would soon ban the killing of hawks and owls, which feed mainly on mice, one of the farmers' most costly enemies. He explained that human beings like to justify their crimes to themselves. So when they get a gun and go out to kill some living things, they turn it on the birds of prey, and commend themselves for it. He reminded his listeners that God had placed on earth a lot of hawks, and had not neglected to provide food for them. One pair of field mice would in the course of a year multiply to 1.000,000, if there were no check, he explained. Each field mouse did perhaps two cents' worth of damage in its life. An owl will eat many thousands of mice in the course of its life. Every form of wild life is of value for some reason or other, he contended.

He listed among birds that are now dwindling in Ontario, the eagles, ospreys, hawks, owls, ravens, pileated, red-bellied and red-headed woodpeckers, bluebirds, tree swallows, some of the warblers, gnatcatchers, snowbirds and crossbills.

Birds that are increasing here, including some newcomers during his experience, are black ducks, turkey buzzards, cardinals, English sparrows, Henslow's sparrows, Bewick's wren, Carolina wren, starlings and pheasants.

"What are we going to do about the Starling?" he said. "We're not going to do anything about the Starling."

"The Electron Microscope"

E. F. BURTON, PH.D., F.R.S.C.

Head of the Department of Physics, University of Toronto.

February 10th, 1940.

Strange as it may seem, the development of the familiar microscope is hampered by the nature of light itself. If an object is smaller than a wave-length of light it cannot be seen. Just as a rowboat is lost to view in the trough of gigantic sea waves, so many an organism escapes detection because it is obscured by colossal light-waves.

Ordinary light is just an electromagnetic wave similar in many particulars to the waves employed in wireless telegraphy. The difference is in the wave-length. Whereas wireless waves have wave-lengths of 100 metres and we receive the signals on our radios, light has a wave-length of from four-to-ten-millionths of a metre, and we receive such signals on the retinas of our eyes, or on a photographic plate. However, even such short wave-lengths are considerably larger than the linear dimensions of many bodies in which the microscope is interested. It is this fact that sets a minimum to the size of particles made visible to us by the microscope.

During the present century, however, our views regarding the true nature of light have changed greatly. In some experiments (as, for example, with the microscope) light acts as though it were merely a wave motion. In other experiments (e.g., the photoelectric cell) we must regard light as corpuscular in nature—a beam of light, according to this view, being a stream of discrete bundles of energy to which the name photons has been given.

Now, from the time of their discovery over forty years ago electrons have been looked upon as very minute, negatively-charged particles moving in clouds or streams, often with great velocity, which may even approach the velocity of light. So, when this duality of light became evident, the physicist began to enquire whether similar duality should not be ascribed to the electron beam. In 1925 it was shown experimentally that an electron beam displayed the same dual nature displayed by light. Consequently an electron beam must sometimes be looked upon as a wave-motion. Moreover, its wave-length is only a very small fraction of that of ordinary light.

The question arose: "Can we have an electron microscope?" and "will it enable us to see particles or structures much finer than the ordinary microscope will permit?" The answer to both questions is "Yes." With the electron microscope magnifications of 100,000 diameters—with the preservation of detail—are possible! The immensity of the step taken becomes apparent when we remember that ordinary microscopes cannot magnify beyond 2,000 without losing detail.

The construction of an electron microscope is made possible because we can bend a beam of electrons by means of electromagnets—in other words, we can make electro-magnets perform the functions of lenses. Electron images can therefore be spread out and focused on a fluoroscopic screen or a photographic film, whereupon they become visible. And, when these photographs are enlarged, new richness of detail becomes evident—detail which is sadly lacking in pictures taken by means of the ordinary microscope.

As electrons bear the same dimensional relationship to particles of air as a football to a house, to avoid obstruction the specimens must be examined in as good a vacuum as man can produce. The result is a huge apparatus which suggests a machine gun rather than a microscope.

There is not a field of science but will be enriched by the "new optics." In the new once sub-visible world we may find whether the mysterious viruses that cause smallpox, infantile paralysis, the common cold and some twenty other diseases are really organisms that were able to baffle detection because of the limitations of light and glass lenses. That and a host of other questions are now thrown open for the scientific investigator.

"Waves, Words and Wire"

J. O. PERRINE, M.S., Ph.D.

Assistant Vice-President, American Telephone and Telegraph Company, New York.

February 17th, 1940.

Sound and Light have always been a part of man's life. When Light joined forces with Electricity, candles and oil lamps were soon superseded and a new day of illumination came into being.

And Sound, since the advent of radio broadcasting, has crept more and more into our lives—the intimate daily lives of millions upon millions of people. Thus the welding of Sound with Electricity has also created a new world for man with his restless curiosity to explore, a world previously inaccessible and, indeed, in some particulars, heretofore non-existent.

The amazing phenomenon of articulate speech has been with us since the beginning of time. Now, with new equipment, we are beginning to understand the mechanics of speech. Vowel sounds—a, e, i, o, u—are of course basic in speech. They belong to the lower set of vibrations in speech. They give tonal qualities to the voice which enable us to identify the person who is speaking. Italian is a fine language for singing because it is rich in vowel sounds and thus gives the performer ample opportunity to demonstrate the quality of his voice.

Most of the consonants, on the other hand, belong to the higher set of vibrations in the human voice. Consonant sounds have little to do with quality of tone. The rasping sound of scraping sand paper has not a vowel sound in it; the sound may be said to be made up entirely of sibilant sounds. Consonants, however, are very important in speech because they produce the sounds which enable one to understand the words spoken. Not until the alliance of speech and electricity as exemplified by the telephone, and not until the application of the vacuum tube to communicating research, did we understand the relative importance of frequency structure in the mechanism of speech.

In the field of modern industry many research problems have been met and conquered. For example, long distance telephone circuits and broadcast circuits have natural enemies that would seriously impair their efficiency if engineers had not discovered some method of combating them. The varying velocity of electrical waves on wires is a very troublesome and complex problem in telephone communication.

Contrary to general notion, electrical waves on wires, particularly along wires closely packed together in cables, do not travel as fast as radio waves, i.e., the speed of light in free space. If one arranges a telephone circuit extending from Toronto to Montreal to New York to Chicago and back again, a snap of the finger into the microphone on the platform will be heard immediately as it comes out of the loud speaker on the stage. A quarter of a second later a second snap of the finger will come out of the loud speaker after the electrical impulse embodying the finger snap has gone around the telephone circuit and back again.

By the addition of an amplifier in the platform equipment, multiple electrical echo was demonstrated. A single electrical impulse after one round trip was made to take a second trip, then a third, a fourth, a fifth, and perhaps a sixth round trip. A single snap of the finger then became a series of snaps out of an electrical impulse equal to the earth's equator. The speed of light and of radio waves is 180,000 miles a second, but on wires electrical waves sometimes travel a tortoisian 20,000 miles a second.

A basic problem in the alliance of speech, music and electricity has to do with dynamic range, or intensity of sounds. In addition to frequency and vibration differences, sounds vary widely in their dynamic range.

The volume range of an excellent radio receiver is about 10,000 to one; that of a full orchestra about 20,000,000 to one, and the human voice about 1.000,000 to one. The human ear is capable of hearing tones a million-million fold louder than the tiniest sound it can hear.

"Naturalists in Venezuela"

GEORGE GAYLORD SIMPSON, Ph.D.

Associate Curator of Vertebrate Palaeontology, American Museum of Natural History, New York.

February 24th, 1940

Venezuela is a land of contrast. It is a country lying entirely in the tropics, and yet, on its mountain peaks 15,000 feet high, there is snow and ice the year round. In its cities there is metropolitan society, cultured and polished; in its tropical jungles there are native savages who have never seen a white man and have never been affected, except in the slightest way, by white civilization.

Among other contradictions, Venezuela was the cradle of South American democracy, for Simon Bolivar, liberator of most of the South American continent was a Venezuelan, and spent most of his life there; and yet it has been ru'ed over long periods by dictators of the worst type.

General J. V. Gomez, the last dictator, died five years ago and after his death there was great confusion. But instead of going at once into another dictatorship, as has so often happened in the bloody and very sad history of that country, the people did achieve—the aristocrats, that is, for there are very sharp social distinctions there—did achieve a government which is democratic in form. So today it is a democratic oligarchy, the only type of democracy which is feasible at the present time in that country.

Since that time Governmental leaders there have striven to bring their country abreast with the other full-fledged democracies of the Western Hemisphere. A small part of this work has been encouraging the progress of science in Venezuela. Many young Venezuelan scientists are pushing the work forward. A few years ago a teacher, Brother Nectario Maria, found some odd looking bones near the City of Barquisimeto, and when he presented his report to one of the scientific congresses there they were at once impressed with the value of the deposits, and secured the services of the American Museum of Natural History, offering to pay the costs of an expedition and turn over half the specimens it could secure.

Caracas, the capital of Venezuela, is twenty miles inland by road (five miles in a straight line). It is cradled in the valleys of the mountains which rise high above the sea. It is a beautiful, tiled-roof city, at an elevation of over 3,000 feet, surrounded by still higher mountains.

Proceeding from the capital, one goes to the City of Barquisimeto, the capital of the state where the deposits were found. It is a very colourful city. A residential law decrees the houses must be painted every year, and every year the owner tries to find some more vivid colour.

The expedition finally set up its summer camp near San Miguel, on the great divide between the Orinoco and the Caribbean. Most of the land in the district is owned by the aristocracy; the workmen, called peons, live in rustic simplicity, under the paternal eye of the lord of the manor.

Many good specimens of paleontological value were secured, most of the specimens dating one or two hundred thousand years ago. These were packed, and then the expedition was asked to accompany a Venezulan party into the primitive area between the Orinoco and the Brazilian border. The trip in was made by airplane.

The party had a fine opportunity to observe at first hand a tribe of primitive indians. These had nice faces and attractive characters, and were very pleasant people, never quarrelsome. They gave a ten-day party which resulted in a colossal eleventh-day hangover. These Indians are skilled with the blow gun. However poison darts from these guns will not kill a man unless they hit him in a particularly vital spot, but will kill animals and small birds almost instantaneously. An Indian skilled with a blow gun could outshoot almost any of us with a revolver, both for range and accuracy. As it is almost impossible to live by hunting they are an agricultural people. The staple crop is Cassava, a root which they bake in great flat cakes and which tastes exactly like wallpaper.

Turning to a different part of Venezuela, in the west in the high Andes there are thriving cities along the routes followed by the Conquistadores three hundred years ago. The smaller towns are often one-street affairs, strung out for miles along the side of a hill. The natives in this section are almost pure Indian. In the middle section of the country the blood is mixed Negro and Indian, in the lower valleys along the seacoast, almost pure negro. The upper classes are, however, everywhere white, mainly of Spanish origin.

"At the Limits of the Microscope and Beyond"

HERBERT FREUNDLICH, PH.D., F.R.S.

Professor at the Institute of Technology, University of Minnesota.

March 2nd, 1940.

Colloid chemistry concerns itself with the study of substances that are in a finely divided state, particles so small they elude the microscope, particles, say, between .0001 and .0000001 of an inch.

Colloidal solutions can be examined under the ultra microscope. We know how a beam of light in a darkened room will reveal dust particles in the air. If a beam of light is projected through a colloidal solution and the solution examined by a microscope placed obliquely to the beam, colloidal particles reveal their presence by scattering the light.

One of the properties of a colloidal solution is that it will pass through a membrane. The so-called invisible viruses will pass through a membrane which excludes larger bacteria; therefore these famous viruses are to all intents and purposes colloidal systems.

When a colloidal solution is placed in a very powerful centrifuge the heavier particles circulating among the molecules of the solvent are driven away from the axis towards the rim. From data so obtained the size of colloidal particles may be calculated.

Particles in a colloidal solution may be solid. Such a solution is called a suspension. The particles need not be spherical. Some are long and narrow, some flat, etc.

Colloids need not be solutions or suspensions. They may be solid. Many solid systems have no visible structure under the microscope. Living things are composed almost entirely of colloidal systems. The muscles, blood, lymph, etc., are all colloidal. Beer and wine, meat, butter, are colloidal. Rubber, silk, cellulose, rayon and tannin are colloidal. Colloid chemistry is fundamental in interpreting many life processes. Solid systems of the sort just described are called gels. Jelly is a typical colloid.

Some jellies liquify when heated. Others can be liquified by simply shaking. They are said to be thixotropic, from the Greek meaning "changeable to the touch."

Some colloids are dilatant. This means they harden under pressure and return to their original state when the pressure is removed. Ordinary moist sand is dilatent. One sample of quicksand that was examined proved to contain a very small amount of a very fine clay which contains iron. This changed the nature of the system, the sand became thixotropic and yielded under pressure, later returning to its normal state.

Science has shown that protoplasm is neither a liquid or a solid, but a colloid that is thixotropic. And yet, to complete the paradox, the muscles of some primitive animals, e.g. molluscs, appear to be dilatant rather than thixotropic!

"The Search for Petroleum in Canada"

GEORGE S. HUME, Ph.D.
Geological Survey, Ottawa, Canada.

March 9th, 1940.

Oil was first discovered in Canada in 1860—about the time it was first discovered in North America. Production has not been large but it has continued throughout the years and some of the older fields like Oil Springs in Petrolia are still producing.

Today Canada produces about 7,743,000 barrels yearly. Total world production in 1939 was nearly 2,100,000,000 barrels, of which the United States produced over 1,250,000,000 barrels. British and mandated territories in the Empire produce three and four per cent. of the world supply. There is no oil in New Zealand, Australia or South Africa. Burma produces about the same amount as Canada. There is some oil in British India and in parts of the East Indies owned by Britain. After the war Britain took over the mandate of Iraq and it now produces 30,000,000 barrels a year. Trinidad produces 19,000,000 a year. British interests also control the Anglo-Iranian Company whose large production comes from Iran.

Oil is found at widely-scattered points in Canada. In New Brunswick there is the Stoney Creek Field which produces 20,000 barrels a year. Two hundred thousand barrels are produced each year in the south western peninsula of Ontario. At Fort Norman in the Northwest Territories there are two wells, and together they produce 20,000 barrels a year. This small amount is of great relative importance because a great deal of the mining development going on at Great Bear Lake and Great Slave Lake depends on this oil for power and fuel. If these wells were not producing the mines would have a much more difficult time operating because the east edge of Great Bear Lake is on the edge of the barren lands, where there are few trees. The oil is of good quality and is being used up to the capacity of the two wells now operating.

The greatest field in Canada is Turner Valley. There are other fields in Alberta of growing importance but today interest is centered on Turner Valley.

Oil and gas are contained in folded reservoir rock which holds the oil like a sponge. The reservoir rocks mostly are porous sandstones or limestones. In fields similar to Turner Valley gas is on the top of the structure, oil below it, and beneath that, water. These materials arrange themselves according to their specific gravity. If the rocks overlying the deposits are impervious to gas, no leakage will occur; but if there is not sufficient cover, seepage results.

On the plains the rocks are flat-lying. In the foothills of the Rocky Mountains the rocks have been greatly disturbed. Much folding has occurred and many faults are found where hard and soft rocks form a series of beds. Evidence of this internal folding may be seen in the structure deep in the earth.

Drilling in Turner Valley began in 1914 near a seepage on Sheep River. Major developments did not follow for some time. In the early days drilling did not reach what is now known as the productive limestone of Turner Valley. However a certain amount of gas was produced from the upper layers of rock.

In 1924 the first well reached this palaeozoic limestone and penetrated it for a short distance. Gas was struck and with it naptha—a high grade gasoline. This well—the famous Royalite No. 4—produced for ten years, yielding 911,000 gallons of naptha valued at $3,000,000. In the early period wells were drilled to secure naptha and this led to overproduction of gas, which was burned giving the large flares for which Turner Valley was famous in its early development.

In 1935 a well drilled further down the flank of the structure encountered crude oil and another phase in the Valley's development began. Work was then available for hundreds of men and the town of Little Chicago developed with boom-town rapidity.

The Turner Valley field is situated in the foothills of the Rockies, with the mountains twenty miles away. It is one of the most complicated fields, geologically speaking, on the North American continent, by reason of its proximity to the mountains. The productive area extends for about 17 miles. The south end is proven for about six miles and there are about 8 wells in the north end. There are almost a hundred crude oil wells in the Turner Valley now.

Production is restricted by the market, which is the prairie provinces. In winter consumption is less than summer. Today the Valley produces about 15,000 barrels a day but much more could be taken without harm to the field.

The foothills stretch from the International Border to the Liard River —an area 800 miles long and from 12 to 20 miles wide. The entire area is prospecting territory in which fields similar to Turner Valley may some day be found. None has been found yet but the structure throughout is basically the same. The structure is very complicated, which makes it very difficult to predict where the palaeozoic limestone will be found in structures favorable to contain oil. Where the limestone has been reached outside the Turner Valley in such places as the Highwood uplift it has contained water, but with drilling other fields will ultimately be found.

East of the foothills on the plains there are tremendous areas not yet adequately tested. In the Red Deer river area near Steveville a large gas well was recently brought into production.

There are several small oil fields on the plains today. No doubt others will be found. Three wells in the Lloydminster area are today producing heavy oil. These wells differ from the Turner Valley wells in that they do not flow. Every well in the Turner Valley flows of its own accord due to the gas pressure, but at Lloydminster the gas pressure is not sufficient to lift the heavy oil. The wells in the Lloydminster area, though only one-third as deep as the Turner Valley wells, have to be pumped.

When drilling a well in the Turner Valley a derrick 84 to 132 feet high is first erected of wood or steel. Percussion and rotary drilling are employed. Rotary drills are now available for deep drilling and there are many wells over 8000 feet, and one well—which, incidentally, produced only salt water—of 10,209 feet.

The rock in the foothills is fairly hard. It costs on the average about $20 a foot to drill a well, or approximately $150,000 for a completed well in Turner Valley. All wells are cased to the top of the producing limestone where the casing is cemented.

There is no question that other fields will be developed in Canada. We shall, however, have to work long and hard before we come into full possession of our national heritage.

"Glass Comes of Age"

W. E. PHILLIPS, D.S.O., M.C.

President, Duplate Safety Glass Company of Canada, Oshawa, Ontario.

March 16th, 1940.

For many centuries the characteristic limiting property of glass has been its brittleness and it is only recently, since science took hold of glass, that we have been able to extend its usefulness in our modern world.

Although glass may be described as a solid in the common meaning of the word, if we are to steer a safe path through the terminology of present day physics we must describe glass at ordinary temperatures as an under-cooled liquid or an amorphous solid. Glass shows no crystalline structure under the microscope. The latest evidence as to its structure suggests it is closely analogous to that of certain liquids in which the atoms assume temporary arrangements, the only difference being that in glass the temporary structure has been "frozen into place." The ability of glass to flow when hot makes it very useful when cast, moulded or pressed into shape.

Ordinary glass, when subjected to sudden shocks, may break into dangerous fragments. Safety glass, which gives a relative measure of

security, has been developed. Two types of safety glass have been developed: laminated glass and heat-treated glass.

Laminated glass is made of two sheets of glass bonded together with an interlayer of suitable plastic. When broken, the glass fragments tend to adhere tightly to the plastic interlayer and hence the danger of flying pieces is minimized.

The other type of safety glass is made by heat-treating ordinary plate glass. The glass so produced is much stronger than ordinary glass. It will twist and bend without fracture and will withstand considerably increased shocks without breakage. Moreover, when this type of glass does break it shatters over its whole area into relatively symmetrical cubic fragments, much like loaf sugar. These crumbles, as we call them, certainly fly, but they are of small mass and thus constitute a much lesser hazard than ordinary glass fragments.

In laminated glass, the function of the plastic interlayer is to absorb as much as possible of the shock of impact and then to stretch—still absorbing work—up to the breaking point.

Until recently, a sheeting of cellulose nitrate or acetate, provided the interlayer in nearly all the laminated safety glass made on this continent. Both these plastics had relatively high tensile strength. The acetate was relatively more stable to light and heat. Neither approached the ideal. An entirely new type of interlayer called "vinyl" or "hi-test" has been developed. It is one of the remarkable new plastics derived from acetylene or ethylene. Laminated glass made from it has about ten times the resistance to breakage at zero Fahrenheit and three times at 110° Fahrenheit that the very best samples of the old type interlayers have. It has many other technical advantages also.

Heat-treated glass is a type of single-layer safety glass widely used on the Continent and in Canada. It derives its safety characteristics from increased mechanical strength. The theoretical "cohesion" or strength of glass is very high. In practice, the strength is probably not one per cent. of the theoretical maximum. Glass should carry 1,000,000 pounds per square inch in tension but in practice it often fails at 4000 pounds.

It is rather interesting to contemplate the possibilities of our attaining something like the theoretical strength of glass. We would have a material with a weight not exceeding that of aluminum, a chemical permanence exceeding that of stainless alloys, a strength exceeding that of the finest nickel steel—and far cheaper than any of these!

Today, at any rate, by heat treating, we have a glass available three to five times stronger than ordinary glass. Even this small improvement has greatly extended the field in which glass can be used.

The method of manufacture is simple. The glass plate is suspended freely in a carefully controlled furnace and the temperature slowly raised

to the softening point. At the critical moment the plate is suddenly chilled by a blast of cool air. This causes a rapid drop in temperature in the two outer layers, which become rigid. As the centre layer cools its outer limits are fixed and it must stretch itself in tension. Heat-treated glass is therefore a three-layer stressed sandwich.

These layers are not visible to the naked eye, but may be demonstrated by means of polarized light. Stresses in the glass itself may run as high as 30,000 pounds to the square inch.

Although glass fibres may seem something of a novelty, there is a record of a dress made entirely of spun glass, as early as 1893. During the world war Germany produced a spun glass substitute for asbestos, by pulling hot glass through orifices in a small furnace. The commercial production of glass fibres from which the finest textiles may be woven is, however, a decided forward step. Such glass fibres provide us with an inorganic textile material unaffected by all ordinary acids and resistant to temperatures as high as 400 and 500° C. All of these fabrics are fireproof, mildewproof, rotproof and washable. The colours used in decorative fabrics are in the glass itself and so are sun-fast.

There are two general types of glass fibre. The continuous type is drawn at a speed of between seven and eight thousand feet per minute from fine orifices in a platinum furnace. As a rule 102 filaments are drawn at the same time, each with an approximate diameter of 2/10000″. This lot of 102 filaments is called a "sliver." Two or more such slivers are twisted together to form yarn, and the yarn so formed is plyed together to make thread, and the thread to form cloth, cords, tapes, braids, etc.

The second type is produced when high pressure steam is substituted for the mechanical drawn process. Drawing speeds up to 60,000 feet per minute are obtained. These speeds result in the formation of fibres ranging from eight to fourteen inches in length. These fibres fall on a fast moving drum and are gathered into a roving and wound on a tube. The material is then treated like any other staple textile fibre.

ELECTED TO HONORARY MEMBERSHIP

in the

ROYAL CANADIAN INSTITUTE

These recommendations were approved by the Council and in accordance with the Constitution of the Royal Canadian Institute the names were presented at the Eighteenth Ordinary Meeting, held on March 16th in Convocation Hall.

Election took place at the Annual Meeting, April 6th, 1940.

FREDERICK GRANT BANTING, K.B.E., M.C., M.D., LL.D., F.R.S., F.R.C.P., F.R.C.S. (Eng.), F.R.C.S .(C.), F.R.S.C.

Sir Frederick Banting was born at Alliston, Ontario, on November 14th, 1891, and graduated in Medicine from the University of Toronto in 1916. He saw service in the Canadian Army Medical Corps as a private before this event and as an officer after it. He was wounded in September, 1918, and received a Military Cross in recognition of his services.

Returning to civil life he practised for less than a year before entering the department of Physiology of the University of Western Ontario in 1920. In 1921 he returned to his Alma Mater in Pharmacology to carry on, with Dr. C. H. Best, a search for the cure of Diabetes Mellitus. That the work has been crowned with great success was promptly acknowledged in 1923 by many universities and other scientific organizations with conferring of honorary degrees and medals. He shared in the Nobel Prize in Medicine for 1923 and in the same year was made first Professor of Medical Research, University of Toronto, a chair established in his honour.

From that time he has continued to be active in prosecuting and directing numerous researches and has published many scientific papers. Dr. Banting served on the Council of the Royal Canadian Institute from 1926 to 1930. In 1934 he was made Knight Commander of the Order of the British Empire (Civil Division) in recognition of the benefits of his work to mankind.

In spite of his labours, Sir Frederick has not neglected the social amenities and his skill with the pencil, in water colours, and in oils is recognized as of no mean order.

Banting has become a household word wherever medicine is thoughtfully practised and we feel that his qualifications will confer honour on our Institute in honouring him.

G. C. ANGLIN. ANGUS MACKAY. ROSS A. JAMIESON.
C. E. COOPER COLE. S. O. ROGERS.

ROBERT ALEXANDER FALCONER, K.C.M.G., D.D., LL.D., D.Litt., D.C.L., F.R.S.C.

Sir Robert Alexander Falconer, K.C.M.G., President Emeritus of the University of Toronto and a past president of the Royal Canadian Institute was born in Charlottetown, P.E.I., in 1867, and spent eight years of his boyhood in Trinidad, where he attended the Queen's Royal College School. In 1885 he won the West Indian Gilchrist Scholarship, which took him to the University of London. Here he spent three years, graduating in 1888 as Bachelor of Arts with Honours in Classics and Philosophy. Then followed four years at the University of Edinburgh where he received the degrees of Master of Arts, with honours in Classics, and Bachelor of Divinity. Later he spent three semesters in postgraduate study at the German Universities of Leipzig, Berlin and Marburg.

Returning to Canada in 1892, he was appointed to the staff of Pine Hill Theological College, Nova Scotia, first as lecturer, and three years later as professor of New Testament Greek. In 1904 he became Principal of the College, and the fine scholar and stimulating teacher became known to a wider public as the wise and skilled administrator.

A few years later the retirement of President Loudon imposed upon the authorities of the University of Toronto the responsibility of seeking a successor. This was a time when universities very generally were being called upon to face many new problems, and the recent University Act had been framed with this in view, particularly in the direction of vesting in the office of President a sane and real authority. The choice fell upon the young Principal Falconer, who assumed his duties in the autumn of 1907.

His first great task, into which he threw his whole energy, was the working out of the recommendations of the Royal Commission which had been appointed to investigate the many problems of the University, whose organisation had become antiquated and unsuited to the needs of a rapidly changing environment.

In this trying period the new President proved himself equal to his task. The enrolment grew apace, the standard of matriculation was raised, new faculties and departments were established, especially in science and economics, and many new buildings were erected.

Although this rapid growth was necessarily checked during the time of the World War, the post-war period witnessed an even greater growth of the University in attendance, in its staff and in buildings and equipment.

The School of Graduate Studies and the University Extension Office were both organized during the early years following the close of the war.

The part played by the President in this development was widely recognized and brought him many honours—his knighthood in 1917 and numerous honorary degreees, not only from sister Canadian Universities but also from many in Great Britain and the United States. Among these were the degrees of D.D. and D.Litt. from the University of Edinburgh, where he studied as a postgraduate student; D.C.L. from Oxford and LL.D. from Glasgow, Dublin, Harvard, Princeton, Yale and many other American and Canadian Universities.

Of these distinctions perhaps the most significant was the invitation of the Anglo-American Society in 1925, to be the incumbent of the Sir George Watson Chair of American History, Literature and Institutions. The lectures were to be delivered in a number of British Universities and Sir Robert accepted the invitation on the understanding that he was to lecture on American History from a Canadian point of view, showing the way in which American influence affects Canada. He expressed a hope that he would be able to show to the British Universities that there existed a Canadian people with a distinct nationality. In appreciation of the honour which the invitation brought to the Provincial University, the Premier, Hon. Howard Ferguson, tendered Sir Robert a state dinner in the Speaker's Chamber of the Parliament Buildings. Soon afterwards he was invited to accept the principalship of his Alma Mater, Edinburgh University, perhaps the most outstanding honour of his career.

The important positions and appointments which Sir Robert has held are too numerous to list here in full. He has been for many years a Trustee of the Royal Ontario Museum and was for some time a Trustee of the Carnegie Foundation for the Advancement of Teaching. In the year before his retirement in 1932 he was elected President of the Royal Society of Canada, and the year after, he was President of the Royal Canadian Institute, which office he held for two years, viz. 1933-34 and 1934-35. His wise advice and helpful interest in the affairs of the Institute will long be remembered and appreciated by those who were associated with him as officers and members of the Council during his term as President.

Many other public activities have marked the period of his retirement. Besides holding many lectureships he was President of the League of Nations Society in Canada, 1935-37, Honorary President of the Canadian Society for Adult Education, Honorary Fellow of the Toronto Academy of Medicine and Honorary Counsellor of the Canadian Red Cross Society in 1939.

In spite of the heavy burden of administrative duties and public activities which Sir Robert has carried during his extremely active life, he has found time to publish many books and articles on educational and public questions and has contributed to professional journals and encyclopaedias both in Great Britain and America. Among the more important

of these publications are: "The German Tragedy and its Meaning for Canada," 1915; "Idealism in National Character," 1920; "The United States as a Neighbour," 1925; "Citizenship in an Enlarging World," 1928; "Immortality and Western Civilization," 1930; Two chapters in Vol. VI of the Cambridge History of the British Empire, 1930; and "The Pastoral Epistles," 1937.

The sponsors of this nomination feel that, in honouring a man of such fine scholarship, broad culture and high ideals, as Sir Robert Falconer, the Royal Canadian Institute will be lending distinction to itself.

ALFRED T. DeLURY. R. B. THOMSON. E. M. WALKER.

JOHN PATTERSON, M.A., F.R.S.C.

Mr. John Patterson, Controller of the Meteorological Division of the Department of Transport of Canada has occupied a very important position as Head of the Meteorological Service of Canada since 1929, and has carried on with great ability the high traditions of that office, and has met the changing conditions brought about by the development of the aeroplane in a most efficient manner. Not only Canada, but the whole British Empire, owes a great debt to Mr. Patterson's work during the last ten or fifteen years.

It is particularly fitting that this honour should go to someone occupying this office, because the connection between the Canadian Institute and the Official Weather Bureau has always been very close. It is a matter of history that the retention of the Weather Bureau at a very critical time was due to the fact that the Canadian Institute took over the responsibility for its working for a period of a few years.

Mr. Patterson has, during his whole service at Toronto, given unstintedly of his time to the two leading Canadian learned societies, the Royal Society of Canada and the Royal Canadian Institute. For many years he served on the Council of the Royal Society of Canada and as Honorary Editor of their Transactions, services which are well appreciated by all the Fellows.

He was Honorary Secretary of the Royal Canadian Institute for a very critical period, from 1911 to 1918. At this time the Council of the Institute was very active in organising the Bureau of Scientific and Industrial Research and in carrying on the education of the public and the Governments to appreciate the importance of scientific research. There is no doubt that the organisation of the National Research Council of Canada, Ottawa, and of the Ontario Research Foundation was a direct outcome of the pioneer work of the Royal Canadian Institute. Recently, between the years 1928-1933 Mr. Patterson served as second Vice-President, First Vice-President and President. His total service on the Council amounts to twenty-eight years, and there is no one who, at the present time, has a better grasp of the history and aims of the Royal Canadian Institute, or a more unselfish interest in the furthering of its aims.

E. F. BURTON   R. F. STUPART   ANDREW THOMSON

J. ELLIS THOMSON, B.A.Sc., Ph.D., F.R.S.C.

We have the honour to present the following facts in regard to the eminent services to science that have been carried out by J. Ellis Thomson.

After receiving his Undergraduate training in the University of Toronto and the Degree of Bachelor of Applied Science, Professor Thomson proceeded to prepare himself by field experience and junior academic work for his chosen field of Mineralogy. In his field work he rendered outstanding service to the Ontario Department of Mines and the Geological Survey of Canada. In his academic work he proceeded through the different grades of the profession to appointment as full Professor in 1933. During this period he also received the degree of Doctor of Philosophy from Harvard University.

Dr. Thomson has been eminent in his work in the Societies of his Profession:

Secretary and Chairman of the Toronto Branch of the Canadian Institute of Mining and Metallurgy.

A Fellow and President of the Mineralogical Society.

A Fellow of the Geological Society.

A Fellow of the Royal Society of Canada.

A Member of the Society of Economic Geology.

A Member of the British Association for the Advancement of Science.

A Member of London Mineralogical Society.

In 1927 he was appointed Honorary Secretary of the Royal Canadian Institute, rendering for four years in this office outstanding services to the Institute and to a large extent initiating the effort to expand the usefulness and Membership of the Institute. He was elected to the position of Second Vice-President and then to the office of First Vice-President, which he held for three years. In this position he not only carried out the duties of his office but also for a considerable time acted as Chairman at the public lectures. In 1935 he was elected President of the Institute and under his energetic leadership the work of the Institute has considerably expanded; one example of this being the increasing influence of the Saturday night lectures in presenting to the general public not only new advances in science but also in developing an added appreciation of the effect of science on our modern life.

Since leaving the Presidential Chair, Dr. Thomson is still taking a very active interest in the welfare of the organization, lending his energies to furthering and expanding the work of the Institute. His ready wit and understanding personality have enhanced and enriched each office he has held.

It is therefore as a scientist, an outstanding leader and a man, that we would respectfully recommend that Honorary Membership be conferred on Dr. J. Ellis Thomson.

THOS. R. LOUDON. WILLS MACLACHLAN SARAH T. WARREN

Membership

(1) Ordinary members are entitled to all privileges of membership, the annual fee being five dollars. Applications for ordinary membership are passed upon at the regular meetings of the Institute.

(2) Associate members are ladies who do not desire full membership. They are admitted in the same way as ordinary members, the annual fee being two dollars and fifty cents.

(3) Life members are elected in the same way as Ordinary members, the Life Membership fee being one hundred dollars.

For further information relating to membership or to the activities of the Institute, address letter to

THE SECRETARY,
The Royal Canadian Institute,
198 College Street,
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PROCEEDINGS

OF THE

Royal Canadian Institute

SERIES IIIA | SESSION 1940-1941 | VOLUME VI

This publication is issued with the object of conveying a general idea of what the Royal Canadian Institute endeavours to do, along with a brief outline of what it has done in the past. The publication contains abstracts of the popular scientific lectures given each Saturday Evening in Convocation Hall, University of Toronto during the 92nd Session 1940-1941.

198 COLLEGE STREET
TORONTO, CANADA

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1941-1942

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Historical Note

ON June 20th, 1849, a small gathering of surveyors, architects, and civil engineers, practising in and around Toronto, met in the office of Mr. Kivas Tully, to form an association of members of the three professions throughout the province. Out of this grew the Canadian Institute.

The original members of the Institute were William E. (later Sir William) Logan, John O. Brown, Frederick F. Passmore, Kivas Tully, William Thomas Ridout, and Sandford (later Sir Sandford) Fleming. Of these, Sir Sandford Fleming, the originator and founder of the Institute, was the last survivor. He died on July 22nd, 1915, 66 years after its foundation. The association was incorporated by Royal Charter, granted on the 4th of November, 1851, and became known as the "Canadian Institute."

Sir William Logan, who was the first president of the Canadian Institute, was succeeded in 1852 by Captain (afterwards General Sir J. Henry) Lefroy, R.A., F.R.S., Director of the Imperial Magnetic Service in Toronto, and later Governor of Tasmania and of Bermuda.

Beginning with the year 1851, there was published by the Institute "The Canadian Journal: A repertory of Industry, Science and Art," under the editorship of Henry Youle Hind, who had conducted explorations in western Canada, and was then Professor of Chemistry in Trinity University. In a later series the Rev. Henry Scadding, D.D., who was president of the Institute from 1870 to 1876, published his well-known series of "Collections and Recollections on Toronto."

Weekly meetings of the Institute have been held consecutively each year from November to April since the Royal Charter was granted in 1851. At the earlier meetings, papers on scientific problems of the day were read and discussed, and practical work was carried on by the various sections which were under the administration of the Institute. The most outstanding of these were the Biological Section, the Geological and Mining Section, and the Historical Section.

About the beginning of this century, it was felt that the discussion of scientific papers did not convey to the public the benefit of the knowledge involved in them, nor the important results that had been attained. In order, therefore, to establish a more direct communication with the public, the system of weekly Saturday evening lectures was begun, with the object of directing the attention of the people to questions of public interest and utility on which scientific opinion might have an important bearing.

A few of the accomplishments of the Institute are to be found on the following pages, and from them it may be seen that the objects of the charter, granted in 1849, have been pursued steadily ever since.

On the 2nd of April, 1914, His Majesty the King granted permission to change the name to "Royal Canadian Institute."

Some of the Outstanding Accomplishments of the Royal Canadian Institute

1. **Co-operation in promoting the meetings in Toronto of the following scientific societies:**

    (a) The American Association for the Advancement of Science, 1889 and 1921.

    (b) The British Association for the Advancement of Science, 1897 and 1924.

    (c) The International Geological Congress, 1913.

    (d) The International Mathematical Congress, 1924.

2. **Standard Time.**

In 1878 Sir Sandford Fleming brought forward the plan of adopting for the whole earth, twenty-four standard meridians, fifteen degrees apart in longitude. He published many papers on this subject, and with the co-operation of the Institute, the zone system of time-reckoning was adopted in most of the countries of the world.

3. **The Museum.**

The Ontario Archaeological Museum was begun under the auspices of the Institute, and continued under its management for six years, before being transferred to the Ontario Government and the University of Toronto.

4. **Publications.**

The Publications of the Institute have appeared in four principal series and one minor series as follows:—

(1) "The Canadian Journal: a Repertory of Industry, Science and Art," and a Record of the Proceedings of the Canadian Institute. 3 vols., 4to. Begun August 1852, ended December, 1855.

(2) "The Canadian Journal of Science, Literature and History." 15 vols., 8vo. Begun January, 1856, ended January, 1878.

(3) "Proceedings of the Canadian Institute." 7 vols. Begun 1879, ended April, 1890.

(4) The Archaeological Reports of the Canadian Institute were published as part of the Appendix to the Report of the Minister of Education for the Province of Ontario. 1886-1904.

(5) Minor Series. "Proceedings of the Canadian Institute." From 1897 to 1904, two volumes of this series, containing short papers, were published.

(6) "Transactions of the Royal Canadian Institute." Begun October 1890, and up to October 1940, Part I of the twenty-third volume has been published. This publication contains scientific papers on technical subjects, relating to all branches of science. These papers are submitted by those doing research work. The publication is sent to learned societies throughout the world, and these societies send their own publications in exchange. Any Ordinary member of the Royal Canadian Institute may receive a copy of this publication upon request.

(7) "Proceedings of the Royal Canadian Institute." Series IIIA. Abstracts of the lectures given during the year. Begun 1936 and to date five volumes have been published.

(8) General Index to Publications 1852-1912. Compiled and edited by Mr. John Patterson. Dr. J. B. Tyrrell, President of the Institute, 1910-1913, undertook to finance the compilation of the index, and made it possible for the Council to proceed with the work.

5. The Library.

As a result of the exchange of publications with learned societies for the past ninety-one years, the Institute has built up a most important scientific library of over twenty-five thousand volumes, many of which are indispensable to scientific workers in this part of Canada. For protection against fire, this library is housed in a section of the library of the University of Toronto, and may be used by the staff and students of the University as well as by members of the Institute.

6. The National Research Council and the Ontario Research Foundation.

In was in large part due to the vigorous campaign of the Institute on behalf of a wider application of science to industry in Canada, that the Honorary Advisory Council for Scientific and Industrial Research, the forerunner of the National Research Council, was appointed by the Dominion Government, and that the Ontario Research Foundation was instituted through the co-operation of the Ontario Provincial Government and manufacturers.

7. University Grant.

The Institute also strongly supported the successful application to the Provincial Legislature for an annual grant for research in the University of Toronto.

Report of the President

1940 - 1941

As presented to the Annual Meeting, Saturday, April 5th, 1941.

During the past year the Royal Canadian Institute has gained certain objectives, has been saddened by the death of valued members, has welcomed new members and has looked forward toward a widening scope of service.

Through all its years of activity the Royal Canadian Institute has had as an object the advancement of science and particularly the presentation of the truths of nature and the methods of science to the general public. It has not been remiss in assisting, and in pioneering for, pure and industrial scientific research, but in a democracy it is ever necessary that the general public shall be made conversant with the objects to be gained by research, advancement in science and the use of the scientific method. It is therefore self-evident that the role played by the Institute in placing advances in science before the public is a most important adjunct to those played by other scientific bodies in developing the industrial, scientific and cultural life of Canada.

A volume of the "Transactions" of the Institute was issued during the year containing important scientific papers on Canadian subjects. These have been sent to almost 400 scientific bodies throughout the world. Owing to the war, they are being withheld from some 266 exchanges usually supplied. Following the practice of the past few years, Volume V of the "Proceedings" of the Institute has also been issued. This volume, which is sent to all members and to the exchanges, contains abstracts of the lectures, the annual report and a list of members.

Arising out of this publication and exchange policy, the Institute has collected a most important library of some 31,000 volumes of publications of many scientific societies from almost all countries. Many of the volumes are not obtainable elsewhere in Canada.

The most severe problem facing the Institute in respect to the Library is the lack of adequate housing. At present, those volumes not duplicated in the University Library are housed there. This amounts to almost two-thirds. The remainder is either in dead storage or on stacks in the Institute headquarters. A golden opportunity is here presented to a benefactor to provide funds to house adequately and make available more readily this most important scientific library.

The membership of the Institute has, through the energies of an active committee, been well maintained. Industrial firms, by taking out

memberships, have again greatly supported the Institute. A new method of school memberships has been developed but adequate time has not yet passed to judge the actual results.

The books of the Institute have been audited and a certificate of the auditors that the books and statements are in good order placed in the hands of the Honorary Treasurer. The Honorary Treasurer will be pleased to show the report to any member wishing to see it. For the year just ended the receipts were approximately $8,200, included in which is a government grant of $500. On the lectures was expended approximately $1,400. On library and publications approximately $2,400, and on administration, building upkeep, office expenditure, etc., approximately $4,100, leaving a small balance. The service of the Institute to the community is greatly handicapped through the lack of funds to carry on the work and all departments are forced to practise the most rigid economy and curtail their work.

The general policy of the Institute has received careful and continued study. Methods have been developed to make available the work of the Institute to the teachers and senior pupils of the schools. A more ambitious development is just at present in the formative stage to make available the work of the Institute to other centres in Ontario and Canada by co-operating with other societies and groups.

Carrying forward the work of last year, scientific books and publications have been collected and have been turned over to the Auxiliary Services of the Department of National Defence for the use of the Navy, the Army, and the Air Force. These, we are informed, have met a real need.

Twenty Saturday evening lectures have been given during the year. The lecturers have come from the Universities, Government Departments, Engineering Offices, Industrial Research Laboratories and Hospitals, the Navy, the Army, and the Air Force, and in all cases without honorarium. Some of the lectures have dealt with scientific aspects of the War, others with industrial developments and others with advances in scientific research and knowledge. An endeavour has been made to cover various fields of interest and to have the subjects dealt with in a popular manner. Almost all the lectures have been illustrated. The attendance has been gratifying.

While certain of the lecturers were in the city, opportunity has been taken to have them meet and discuss specific problems with University students, University committees and other groups.

Publicity of the lectures has been carried out by placards in the University, schools, industrial firms and military offices and camps. The daily papers have been very generous with advance notices and reports of the lectures. University, professional and trade journals have also assisted. At times the lecture of particular interest to a special group has been drawn to its attention by letter.

Many ladies and gentlemen have greatly assisted in entertaining the lecturers while in Toronto. These occasions have made it possible to meet the lecturer socially and to arrange that he see points of interest to him in Toronto.

Each year the Institute is saddened by the death of some of its members. This year we have lost two honorary members, Sir Frederick Banting and Sir Frederick Stupart, as well as other members who have done much to enhance the value of the Institute. This loss is greatly felt and the sympathy of the Institute has been extended to the families. The Institute has been fortunate in having had the assistance, support and guiding hand of these members for many years, and their influence in the Institute will live and aid in developing Canada.

Each year the Institute loses members of its Council. This year from the Council the following retire: Mrs. F. N. G. Starr, Dr. C. W. Drury and Professor C. R. Young. They have served the Institute well, and it is hoped that their advice will be available in the future. There also retires Dr. J. Ellis Thomson as an ex-officio member after fourteen years of service as Secretary, Vice-President, President and ex-officio member of council. His wit, energy and wisdom will be greatly missed.

I am sure that the membership would wish me on their behalf to thank the members of the Council and committees for their unceasing efforts to make the work of the Institute a success. It is difficult to mention names but because of specific duties certain members have given much of their time and ability: George C. Gale, Honorary Treasurer; Professor E. M. Walker, Honorary Editor; Professor E. Horne Craigie, Honorary Librarian; and Professor Ellis Thomson, Chairman of the Membership Committee. Although the Institute has not designated an office as Honorary Organist, Mr. T. H. Mason has most efficiently and pleasingly carried out the duties of that office. The thanks of the Institute are gladly extended to these men who have so readily and adequately performed the duties placed upon their shoulders.

Possibly until one holds the office of President one does not realize the multitudinous duties so admirably carried out by our Executive Secretary, Mr. D. Bruce Murray. The smooth and efficient operation of the Institute owes much to this able, tactful and energetic Secretary. I am sure that I but voice the feelings of all in thanking Mr. Murray for his unfailing assistance.

No organization can stand still or rest on its laurels. Canada at war is a challenge and an opportunity to serve. The Royal Canadian Institute, experienced by its splendid past, spurred by the need of the moment, will go forward to greater service in the Canada of the future.

Membership.

(1) Ordinary members are entitled to all privileges of membership, the annual fee being five dollars. Applications for ordinary membership are passed upon at the regular meetings of the Institute.

(2) Associate members are ladies who do not desire full membership. They are admitted in the same way as ordinary members, the annual fee being two dollars and fifty cents.

(3) Life members are elected in the same way as Ordinary members, the Life membership fee being one hundred dollars.

For further information relating to membership or to the activities of the Institute, address letter to

THE SECRETARY,
The Royal Canadian Institute,
198 College Street,
Toronto, Canada.

The Saturday Evening Lectures

One of the objects of the Royal Canadian Institute is to further a popular interest in research. Since the results of research are so far-reaching in their effect upon the life of every member of the community, it is necessary to create an intelligent public who will be able to follow the work and achievements of those who are engaged in it.

What has been done in the past is illustrated by such important accomplishments as the invention of the telephone and the radio, the discovery of radium, the improvements of the telescope; also by the immense access of knowledge as to the structure of matter, whether in the atom or the universe, the manifold phases of life on the earth, and the exploration of the world.

The lectures of the Institute are the medium whereby such work is explained to the public. On Saturday evenings during the season, popular lectures of a scientific nature are given by men outstanding in their own field. The purpose is to interpret scientific research for the public.

"The Electric Utility in Canada."*

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PRESIDENTIAL ADDRESS

Let there be light. Down through the ages has come this cry. Primitive man seeing the sun rise and dispel the darkness, seeing the moon give light at night and a forest fire light up the countryside, endeavoured to make light himself so that at night he could see and in the dark caves could carry on at his work. The torch, the lighted faggot, the wax candle, the oil lamp and the gas jet served his purpose to a limited degree but man was always searching for something more satisfactory. To assist him in his work he domesticated animals and by the lever, the wedge, the roller and the wheel, endeavoured to relieve himself of physical labour. Later, by using the power of running water and, much later, that of steam, he was able to gain leisure from his labours and rise to higher achievements.

It is difficult for us today to realize that it is only within a comparatively short period of time that the practical application of electrical power has made available those many aids to our modern life that we call necessities.

Men working through all ages have been gathering facts and with these facts have endeavoured to interpret the laws of nature and apply them to their own purpose.

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In 1791, there was a baby born into a blacksmith's family in England. He was Michael Faraday. As the boy grew up he was apprenticed to a book binder, and later came under the notice of Sir Humphrey Davy. He was appointed as an assistant in the Laboratory of the Royal Institution of Great Britain and during the Thirties of the last century carried out investigations which so clearly developed, resulted in his report of 1841. His findings might be simply expressed as follows: a wire moved in front of a magnet has a current of electricity induced in it; a wire through which a current of electricity is flowing, placed near a magnet, moves.

*This paper was illustrated with 64 lantern slides and a Kodachrome motion picture.

In 1818 James Prescott Joule was born near Manchester. As he grew up he became interested in scientific research and, inasmuch as he had independent means, owning a brewery, he could devote time and energy to the development of his researches. The discovery having been made that a wire or a fine filament of carbon was heated by a current of electricity flowing through it, he formulated, in 1840, a quantitative statement of the law according to which heat is produced in a wire by the passage of an electric current.

Just prior to the time of these statements James Clerk Maxwell was born in Edinborough. He was educated in Scotland and later held professorships in Aberdeen and London and was the first Cavendish Professor in Cambridge. Among the many great things he did in his life, possibly his mathematical interpretation of Faraday's work was among the most far-reaching.

There is no doubt that in any outstanding interpretation of the laws of nature the work of many men is found. It might also be likened to the building of an arch, and in the arch that is the foundation of the electrical industry of today, we find the triple keystone placed by Faraday, Joule and Maxwell. And out of their work has come the generator, the motor, the incandescent lamp and all of the heating appliances from the simple domestic iron to the huge industrial heating furnaces.

We turn now from the physicist and worker in pure science to those who have adapted the truths that have been found and in the electrical industry the name of Thomas Alva Edison looms large. Born in 1847, he started to work at the age of 10 and at 15 years of age was a telegraph operator. It is not my intention to trace the work of Edison in his many researches and developments at Menlo Park, except to point out that in his perfecting of an incandescent lamp on October 21st, 1879, and in his development of a direct current generator, he laid the foundation for a tremendous industry. It is only fair to point out that, almost at this time in England and independently, Sir Joseph W. Swan developed an incandescent lamp, but this does not detract one iota from the importance of the work of Edison. The problem then was to make use of this development. Instead of having small generators placed in each factory or each residence, the idea was conceived of placing the generators in a central station, carrying the wires through the streets and serving electricity into factories, stores and residences to be used in the incandescent lamps. It seems simple today, but looking back to those days one must remember that there were no cables, practically no electric wires, no underground cables, no switches, no fuses and no meters. The whole of the electrical industry has been developed since that time. Edison's first work was carried out in New York City. A central station was constructed on Pearl Street. Underground conductors were made by placing two copper rods of semicircular cross section in asphalt, in a pipe. Between these rods were placed two small wires. These sections, measuring about 20 feet long, were joined

together by copper castings which were covered with asphalt in a box. And so the cable was made and laid in the streets and houses and stores connected to it. The two small wires were connected to the rods at the end of the cable and to a voltmeter in the power house. This was done so that the operator could tell the voltage at the end of his circuit and compensate for it. I hold the original of this cross section in my hand. Crude, but this was in 1881 and the first installation of the Edison Two-wire System, installed under the personal supervision of Edison. The Edison Three-wire System was still long in the future. The Pearl Street Station was opened for service on September 4th, 1882.

Acting independently of Edison and working in England was a young man Sebastian de Ferranti, who was born on April 9th, 1864. Instead of working with direct current, Ferranti worked along the line of alternating current and in 1878 designed an alternator and patented it in 1882. In some of this development he worked with Lord Kelvin. In 1886 he was Engineer for the Grosvenor Gallery Company and later with the Electrical Supply Company of London, England, and developed a distributing system, using underground cables at ten thousand volts, alternating current.

One is tempted to go down the many byways that are presented by the works of Tesla, Stanley and Westinghouse but I would rather draw your attention to a young man who was born in Newark, N.J., on February 12th, 1860—John William Lieb. He had been educated along scientific lines as a Mechanical Engineer and was first employed as a draftsman and later as first electrician of the Edison Electric Illuminating Company of New York, being in charge of the Pearl Street Station. In 1883 he was sent to Milan, Italy, to install the Edison System, and while in Europe investigated the alternating current system, particularly the transformer which had been developed in Vienna, and strongly recommended to Edison that this system be adopted. The direct current system is limited to the voltage of the generator, whereas in the alternating current system the most suitable voltage is chosen for the generator. A transformer then increases this voltage to the most suitable for transmission or distribution and transformers placed at the point of consumption, reduce the voltage to that suitable for the consumer. Today the alternating current system is in universal use. However, those connected with Edison at this time were so wrapped up in the details of the direct current system that Lieb's advice was not followed.

One interesting story told many times by Mr. Lieb was that while he was in Milan attending an opera at La Scala, he was called out, as some of the street lights were not working, and in opera cloak and silk hat climbed the pole and made the necessary repairs. Later, John Lieb was to be the guiding hand of the New York Edison Company as First Vice-President and General Manager and, during the last war, was recalled by the National Electric Light Association, the then National Association of Electrical Utilities in the United States, to be their war time president. It

is my humble opinion that John Lieb probably did more to develop the electric utility in the United States than any other man and he did much to present the personality of Leonardo Da Vinci to the American public.

The development of the modern electrical utility has gone through various stages. First—small plants because of limited voltages served small communities. With increase in voltage and the adoption of alternating current, larger communities were served. The increased transmission voltage made possible the development of large hydraulic power plants and the transmission of the power great distances to industrial centres and led to the huge networks of today. This development in Canada we will trace and see that men as well as scientific laws and machines go to make up the electric utility.

In the early 1880's many reports of the astounding advances in the development and use of electricity appeared in the press and Edison generators were installed in some of the cotton mills and other industrial establishments. At Pembroke, Ontario, there was a grist mill run by water power and owned by W. V. McAllister. An Edison generator was purchased, wires were run on the streets of Pembroke and service to the stores, residences and streets began on October 8th, 1884. Up to this time there had been installations of arc lamps in various parts of Canada, but this, as far as can be learned at the present time, was the first of what we might call an electric public utility operated in Canada. Installation was made by Ahearn and Soper of Ottawa. In 1889 the Pembroke Electric Light Company was organized and has operated continuously from that date to the present. There was continued development here. When they found that the steam plant installed in 1893 was not big enough, a hydraulic plant on the Black River was installed and more recently a Diessel Engine as a reserve. It is interesting to note that the present Manager, Mr. J. A. Cone, started with this Company in 1887 and has been continuously employed with them since that date. One cannot mention the Pembroke Electric Company without giving great credit to the late Hon. E. A. Dunlop for the strong guiding hand that he had in developing a utility in Pembroke adequate to the needs of the community and maintained according to the highest practices of the art as they developed through the years.

About this time, June 6th, 1886, a number of men from Eau Claire, Wisconsin, arrived in Calgary, Alberta, and started to build a saw mill, their first drive being in the spring of 1887. A small direct current generator had been installed by others in Calgary but it was not giving very adequate service. In Eau Claire, Wisconsin, since 1883, there had been two electrical companies operating and it was therefore logical that in 1889 an electrical generating plant was installed in the Calgary saw mill run by a Corless Engine the steam coming from boilers run from saw mill waste. Before this plant was allowed to go into operation, there was considerable controversy between those interested in the old plant which was direct current and the new plant which was alternating current. Some time previously in

the United States an alternating current generator had been presented to the Government and supplied the current that was used to electrocute criminals. The claim of the direct current exponents was that their power was absolutely safe, and people did not wish to use this undoubtedly dangerous alternating current, since it was used to electrocute criminals. This absurd statement is entirely untrue, although occasionally one still hears the myth. It is amusing to read of this same controversy developing in Calgary at about this time. However, those interested in the power plant in the saw mill were able to carry the day and primaries at 1000 volts were carried on the streets—50 volts being used on the secondary and in the residences. In 1893 a water power plant was installed and ran very successfully. An intensely interesting story of these early days in Calgary has been presented by Theodore Strom, first Engineer of the plant.

> "I remember coming into the Eau Clair office one day when R. B. Bennett was there. He turned to me and said 'Your lights were pretty poor last night, Theodore, I could hardly find my bed.' The manager spoke up and said 'Theodore couldn't help it. We had an ice jam somewhere on the river last night and we were short of water.' Mr. Bennett said, 'Short of water, that's funny, the lights looked as though they had too much water in them.' "

In Mr. Strom's interesting reminiscences he tells of operating problems from high and low water, of difficulties with collecting consumers' accounts, of maintaining services, of repair of consumers' apparatus and diplomatic discussions with Government Inspectors. The public utility official of today would see many of the public relations problems shaping themselves in the early times. He would also realize that the necessity for a clear-cut policy was receiving serious consideration by the executives.

In the modern developments in Calgary and those of many cities and towns of the prairie provinces as well as developments in Central and South America, a Canadian, G. A. Gaherty, President of the Montreal Engineering Company and of the Canadian Electrical Association, has taken a leading part.

In 1881 the Ottawa Electric Company was formed to supply arc lamps in the City of Ottawa. Shortly after this a recent graduate in Engineering, John Murphy, was employed by Thomas Ahearn to operate this plant. It is interesting to quote from Mr. Murphy the following:—

> "The electrical equipment consisted of three arc light dynamos with the capacity of the three of them totalling 16 Horse Power. The three of them were driven by a little water wheel; two wires were run from each dynamo direct to the lamps and there were no service ammeters or voltmeters within ten miles of the plant. The entire system was controlled by hand and it rendered ideal service. If the lamps were not burning brightly, the water wheel gate was opened and the machinery speeded up a bit; if they were too bright, the opera-

tion was reversed. If it became necessary to work on a service while it was in operation, one of the brass binding screws on the dynamo was loosened with bare hands and the wire pulled out of the post. The arc was finally broken by pulling the wire further and further away."

Prior to assuming his duties in this plant in Ottawa, Mr. Murphy had operated a small generator in a saw mill and it is interesting to note the difference between the size of the generator installed at that time (two horse power) with the present Bryson Plant of the Gatineau Power Company now on the same site.

In 1887 the Chaudier Electric Company supplied incandescent light to Ottawa, the voltage being 500 V. direct current with five lamps in series. In 1889 a change was made to alternating current. Later we find the same low water trouble that occurred in Calgary and in 1893 a steam standby was erected to take care of the variable flow of the river.

Back of this whole development of electrical power in Ottawa, as we have seen in Pembroke, was the man who was later the Hon. Thomas Ahearn, Privy Councillor. Thomas Ahearn was born of modest parentage in the city of Ottawa and was employed as a telegraph operator and early formed a partnership with Mr. A. Y. Soper. Their development carried them through the telegraph and telephone stage and through all of the early development of power in and around Ottawa district. In going over the development of power in Canada, time and time again one comes across the name of Thomas Ahearn, always searching out to the new and it was only fitting that he should be chosen as the chairman of the Broadcasting Committee of the Diamond Jubilee, 1927, who arranged the first Trans-Canada Broadcast.

In 1894, these various companies in Ottawa were combined and we find as General Superintendent a young man who had received his early education in the City of Quebec and who had recently come to Ottawa as Superintendent of the Chaudier Electrical Company. A. A. Dion from that time until his death a few years ago, gave of himself in developing an adequate electrical service for the City of Ottawa, in serving the Canadian Electrical Association and in giving wise council to the various engineering organizations in Canada. He was a leader who could be relied upon in any emergency. The development of the electrical utility in Ottawa, has kept abreast with the best engineering practice and is now under the care of a Canadian who has had experience in power development and utility management, not only in Canada but in Europe and South America, Major W. H. Munro, General Manager of the Ottawa Electric Company and President of the Electrical Employers Association.

In a very similar way electrical utilities were being developed in the cities and towns of Canada. Montreal, Toronto, Winnipeg, etc., were being served, each from its local plant for the most part driven by steam power.

Sir Herbert Holt, a Civil Engineer with railroad experience, became interested in developing an adequate service for Montreal and shortly we see power plants installed at Lachine and at Chambly.

J. J. Wright, an Englishman, born in 1850, came to America in 1870, and at the Centennial Exhibition in 1876 met, and later worked with, Thomson and Houston, two science professors in a Philadelphia High School. In 1883 Mr. Wright came to Toronto and from then on, as far as electrical development in Toronto is concerned, his name loomed large.

Benjamin Franklin Reesor of Lindsay was responsible for many plants in towns such as Lindsay.

In this way, we find in the various cities and towns in Canada small electric systems being developed, the radius of their operations being very limited, owing to the necessity of using low voltages; first 52 volts and afterwards with the use of alternating current, being able to use a primary voltage of 2200.

The tremendous potential power of Niagara Falls was always a challenge and many attempts had been made to develop a plant that would make power available. In the late 1880's extensive studies were carried out on this idea, the thought ranging from supply of water power to individual mills and allowing them to develop their own power, or to a central station supplying power to the mills. Quoting from Edward Dean Adams, one who was very interested in this development, we find the following:

> "When the original development of the Niagara Falls Power Company was contemplated, we had no idea what shape the power would eventually take—whether it would be electricity, compressed air, water under pressure or what not. We did determine to make an exhaustive investigation, to consult the best engineering talent in this country and in Europe and after that to map our future course. Of one thing we were certain, we would use water from the Niagara River above the Falls and discharge it again into the river below the Falls, and no matter what system of power development was adopted, a tunnel was required. In order to save time we started to build a tunnel before we came to any conclusion about the type of equipment to be used in the power house."

Would financial men of 1940 go ahead with such a project under such conditions? After very considerable investigation by the International Niagara Commission which met in London, England, and upon which was Lord Kelvin, on May 6th, 1893, a decision was arrived at to use alternating current 3-phase at 25 cycles and the orders were placed for a 5000 H.P. generator.

Two stories are current as to the choice of 25 cycles; one that this was set by the most efficient speed of the hydraulic turbine, the other that it was a compromise between the frequency of 40 cycles then common in Europe and 10 cycles, the most efficient for the then rotary convertors to

carry railway load. Ranged on the side devoted to direct current were Edison and Kelvin and on the alternating current side were Westinghouse and Ferranti. So was launched the development of power at Niagara Falls and the possibility of the transmission of that power.

A few earlier cases of transmission of power had been carried out, such as that of the Telluride Power Transmission Company in Colorado during the winter of 1890-91. These cases, however, were much smaller than at Niagara.

It is difficult to state which was the first transmission of power in Canada, but certainly the power plant at Ste. Narcisse transmitting power to Three Rivers was among the earliest and very probably was the first in the British Empire to transmit power a distance of 18 miles. This plant went into operation between 1894 and 1895. It is interesting to see the early power plant and transmission line and also to see the present development at this point. Copper from this early transmission line is used in making the Bronze Medals of the Canadian Electrical Association for award to employees of the public utilities in Canada for successful cases of resuscitation from electrical shock.

Owing to the fact that increased power was needed in the city of Montreal and to the fact that there was considerable potential power on the Ste. Maurice River, the Shawinigan Water and Power Company was incorporated on January 5th, 1898, to develop power at Shawinigan Falls, and construction was started in the winter of 1899. Hydraulic power was first delivered to the Aluminum Company of Canada on July 1st, 1901, and following the practice of those days an endeavour was made to locate near Shawinigan, industries, particularly of a chemical character, which would require considerable amounts of power. Transmission of power at 50,000 volts to Montreal, 85 miles distant was completed on March 1st, 1903. As in all power companies operated on the river, the storage of water and the balancing of load between power plants has received careful and considerate investigation by the officers of the Shawinigan Power Company during the whole of its existence. This has necessitated dams and power plants over all the reaches of the Ste. Maurice and some of the more modern developments are interesting to view.

One can hardly think of the Shawinigan Company without associating with it the name of Julian C. Smith. Born in 1878 in Elmira, N.Y., he completed his undergraduate education at Cornell. After having experience with Wallace C. Johnston at Niagara Falls he came to Shawinigan in the early years of this century. He had great ability not only in purely engineering matters but also in the many problems with which a chief executive has to deal, marking him as one of the outstanding men in this field in Canada. However, to those who knew him Julian C. Smith will be remembered best for his assistance to engineering organizations, counsel to Universities and quiet guiding advice to those who sought his assistance. On June 24th, 1939, Canada lost a man whom it could ill afford to lose.

Hamilton, Ontario, had the usual experience of cities in the development of power—a local steam plant serving a local community. About 1896, the Cataract Power Company was organized to develop power at De Cew Falls. Water rights were completed in 1897 and the plant put in operation and power transmitted to the City of Hamilton in 1898. It is interesting to note that the Engineer who built the power plant at De Cew was a Canadian born in Brantford, educated as a Civil Engineer and spent his early life in railway construction. Lieutenant-Colonel Reuben Wells Leonard is probably known to Canadians and particularly to the Universities of Canada as a benefactor in many fields, but as a young Engineer he was the builder of the first plant on the Canadian side of Niagara Falls, of the plant at De Cew Falls and later the Kakabeka Plant of the Kaministiquia Power Company near Fort William.

It was not a simple thing to convince manufacturers, even in 1900, that electrical power was as satisfactory as their steam plants. I quote from a statement of W. G. Angus who was connected with the Cataract Power Company from the building of De Cew.

> "An interesting thing happened at what was known as the Ontario Coloured Cotton Company when we were trying to get the business. They got a slug of water over from the boilers and punched the end of the high pressure cylinder and shut down the mill and they were in trouble. I had up in the old Hamilton Electric Light Company a large motor. I took it down there and put it in the mill in the loom room on the first floor and eliminated the belting that ran back into the engine room. It was a question whether it would carry the mill and we started it up and made a temporary job of it. We got the mill running and it ran, showing a pretty considerable saving between that and the engine. After they got their engine fixed and the question came up to get the motor out, I went to Mr. Dexter several times and he always put off letting the motor go. Finally the truth came out that the good speed regulations in the electric drive had demonstrated a considerable saving in what they called seconds. That is, the steam engine varies in speed up and down, especially old machines. He found he had eliminated a lot of seconds by the close regulation in speed which he got by the electric drive. That got us a big customer."

It would be impossible to cover the many developments of the early days of this century. The Canadian Niagara Power Company, Ontario Power Company and Toronto Power Company were building plants on the Canadian side of Niagara Falls. Power was transmitted to the City of Toronto in the Fall of 1906.

Owing to the growth of load in Winnipeg, power was developed at Pinawa Channel and transmitted to Winnipeg in 1906.

We have seen how the scientific truths enunciated by research workers were taken by inventors and the results of their labours welded into

small power plants to serve small towns or the small part of a large city. We have seen where these plants have been consolidated together due to the possibility of primary voltages up to 2200 volts. Later, large blocks of power were developed and transmission lines with voltages up to 50,000 carried out, but for the most part, carrying these large blocks of power from the point of generation to a large distributing point.

Investigations were now carried out in a number of points, which resulted in the tying together of a number of power plants by transmission lines and serving a number of towns or cities. About 1909 such a system then known as the Electric Power Company was organized by the late Cecil B. Smith. Mr. Smith was a Civil Engineer, a Professor of McGill University, the first Chief Engineer of the Hydro Electric Power Commission and at the time under consideration was a Consulting Engineer. By developing a system in Central Ontario, tying together a number of Power Plants on the Trent River, a system was organized to supply the district bounded by Oshawa on the west, Napanee on the east and Tweed, Peterborough and Lindsay on the north.

A very similar type of system was organized a few years later by a recent graduate in Engineering of McGill, Mr. J. B. Woodyatt. This tied together a number of power plants in the southern counties of Quebec and fed through a network of transmission lines such towns as St. John, Drummondville, Sherbrooke, Ste. Hyacinthe, etc.

Possibly one of the most celebrated networks was organized by the late Sir Adam Beck; this network being the Niagara System of the Hydro Electric Power Commission. Taking power from the Ontario Power Company at Niagara Falls a one hundred and ten thousand volt transmission line was extended to Dundas and then to Toronto, Guelph, London and a number of other cities in southwestern Ontario. Many of us well remember the first Sunday in September, 1910, when power was first turned on to this system for test and later that fall for commercial service. In mentioning the Hydro Electric Power Commission, it is impossible not to associate with it the name of Dr. F. A. Gaby. This Engineer gave richly of his experience, training and ability in the development of this now vast system.

With the growth of the requirements of the Province, the meagre beginnings in 1910 were greatly augmented about 1917, when construction was started on the Chippawa-Queenston Development where instead of just using the drop of the water at the Falls alone, use was made of as much as possible of the drop from Lake Erie to Lake Ontario. The requirements for power at the head of Lake Superior were the reason for the development of Nipigon Power Plant on the Nipigon River. More recently Chats Falls was built on the Ottawa River above the city of Ottawa and using that power and other power purchased from the Gatineau Power Company a transmission line at 220,000 volts was built to the City of Toronto, reaching it at the town of Leaside where an extensive substation and distribution

centre was installed. In this way, from small beginnings, a tremendous power organization to supply power to the Province of Ontario has been developed.

On almost like scale, developments have been carried out in the other Provinces.

One comparatively recent extension of electrical service, is the extension of electrical service to the rural communities. Now on many farms in Canada, electrical service is almost taken for granted. Lighting, milking and many other services are carried out electrically.

This huge electrical utility is in the able hands of Dr. T. H. Hogg as Chairman and Chief Engineer. Many of the power plants we have seen came under his supervision when he was Chief Hydraulic Engineer. He is now giving to the people of Canada the benefits of his international engineering experience and to the engineering profession the guiding hand as President of the Engineering Institute of Canada.

It would not be a true statement to say that all of this work has been carried out without setbacks, without vast problems to solve and particularly without trying to cope with the forces of nature. In 1909 a bad ice jam formed in the lower Niagara River, the water at the Ontario Power Company rose 42 feet, entirely swamping the power plant. At this time, I was Electrical Superintendent of a consumer of the Company. We had had certain short shutdowns prior to this and I remember well the morning, calling up the Superintendent of the Ontario Power Company and asking him how long we would be off this time and receiving the advice that we would probably be off six months. However, by making certain arrangements, they were able to supply power very much sooner than six months. In 1938 another ice jam formed in the river and again the Ontario Power Company was not only flooded out but the power house was jammed with ice and steam shovels had to be used to remove the ice from the power house. By the skill of local engineers, a method of vacuum drying was put into effect and it was possible to dry out the generators and put them back into service without rewinding, excepting in one case where the generator was almost due for overhauling.

In 1898 an extremely bad sleet storm hit Hamilton and Toronto, pulling down structures of the local utilities. Wires, poles and trees made a terrible mess on the streets. This type of trouble has been taken care of to a certain extent by more solid construction and tree trimming. However, at times snow piles up about 2 feet in diameter on some wires in rural districts, putting a tremendous load on the wires and at times, as in Toronto in 1926, sleet is King. We are also subjected at times to bad wind storms or hurricanes coming through parts of Ontario and although towers of transmission lines are strongly built, yet at times they cannot withstand the pressures placed upon them.

It is at these times of trouble that the power organization is tried to its utmost; then it is that linemen, operators and maintenance men show

what they are made of, many times working for extremely long periods in the worst kind of weather, to try to restore service or to maintain services, which is the ideal of all electrical utilities.

Mining operations in the Cobalt field in 1907 required compressed air and it was not long before a power plant was in process of construction on the Montreal River and another on the Matabitchouan River. These plants were the starting of the system of the Northern Ontario Power Company, supplying power first to Cobalt, Haileybury and New Liskeard and later the Gold Mining Camps of Timmins, Porcupine and Kirkland Lake. At a more recent date a large plant was built on the Quinze River in Quebec and fed into this system. This system was also extended to supply power to the copper and gold mines of Northern Quebec.

One cannot think of the Northern Ontario Power Company without recalling the great service of its creator the late J. Homer Black—telegraph operator, school teacher, railway superintendent, power superintendent and executive. It will be a long time before the North will forget what it owes to this leader.

The Hydro Electric Power Commission purchased a plant that was being completed by the Abitibi Power and Paper Company, some 76 miles north of Cochrane at Abitibi Canyon, and transmitted this power over a high tension transmission line to the city of Sudbury. Many other power developments have been carried out in the far northern parts of Canada to supply the growing needs of these mining camps and cities. It is very interesting to view a more recent development in the building of transmission lines through the far north bush.

For very obvious reasons I have not used maps and so have been prevented from showing the growth and completeness of the electric utility in Canada. I have also refrained for the same reasons from giving a description of the developments in the west and east maritime provinces of Canada.

It could have been possible to show the development of a high standard of construction of the electrical plant in the cities of Canada, where some substations look more like libraries and others like modern residences, except when one sees the back yard.

It would not be fitting to close without mention of the admirable group of men and women who are the backbone of the utility industry. You have seen the construction linemen at work and I can assure you that the operating lineman is a man, many times tried and never found wanting. The maintenance men, operators, load despatchers and system supervisors and a host of others, are serving twenty-four hours a days and three hundred and sixty-five days a year. Many even eat their Christmas dinner on the job so that service will be maintained. Is it small wonder then that those of us who have lived our lives in utility work are proud of these men, of their esprit de corps and resourcefulness in emergency?

Canada is rich in water power and this water power will no doubt be developed so that cities may be served, the industrial plants supplied with power and the rural communities receive many of their benefits from the use of electricity. All of these things, however, will come about by the leadership of engineers and utility executives upon whose shoulders will be the responsibility of directing that host of linemen, operators, maintenance men, engineers, draftsmen and others who will make possible the application of the truths of science for the benefit of mankind. "May wisdom teach them what to do as cleverness has taught them how to do it."

"Adventures in Electricity"

PHILLIPS THOMAS, PH.D.

Westinghouse Research Engineer.

November 9th, 1940.

Dr. Thomas, a Westinghouse Research Engineer of many years' standing, demonstrated a number of electrical principles functioning in unusual practical applications today.

One of the most unusual was a bacterial death-ray utilizing a certain sector of the ultra-violet band to kill bacteria. The toxic effect of the radiation is in direct ratio to its intensity. Bacteria can be killed by four flashes lasting one-millionth of a second each. The principle has been applied commercially. A battery of lamps installed directly over the operating table in a southern hospital cut down fatalities from infection under the knife by more than 95 per cent. over a three year test period. The general idea is that all air-borne infection is eliminated.

Another interesting machine was the stroboscope (literally, whirling-watcher). It provides an effect which might be termed movies in reverse, because it can make an object such as a rapidly moving flywheel appear to be stationary, by producing a flash of light so timed that the eye sees the object under observation at precisely the same point in each revolution. The eye holds over the successive images by means of persistence of vision. The super-stroboscope used in the demonstration has a 3,000 candle-power flash lasting one one-millionth of a second which can be repeated the desired number of times per second.

Dr. Thomas believes the gyroscope—represented in its most elementary form by the mechanical top that spins on the rim of a cup—has possibilities in precision control work hitherto overlooked. This is because of the anticipatory characteristic of the precisional torque, which responds to velocity rather than change itself.

A new method for determining strains and stresses in metal was demonstrated. Models are first made to scale in bakelite, subjected to stress and examined under polarized light. Colour patterns appear which reveal the points of maximum stress. If the bakelite pieces are first heated to the boiling point of water and then subjected to stress till the pattern indicating the point of maximum stress has been reached, and is then allowed to cool, the patterns are "frozen in" and the model can be taken from the frame and examined at leisure. Very accurate computations can then be made so as to overcome disabilities in the original structures.

Dr. Thomas subscribes to the homely philosophy that no man thinks unless he has to. He pointed out that when oil rings were first introduced

to deliver a supply of oil to shafts and bearings, the rings as originally conceived delivered a none too copious but adequate supply of oil, but that with the development of heavier bearing loads and faster-moving shafts a better supply of oil was imperative—a condition which was very simply met by grooving the ring. He pointed out the improvement might just as easily have been effected when the ring was first introduced.

"Disease in Plants"

D. L. BAILEY, M.S., PH.D., F.R.S.C.

Associate Professor of Plant Pathology, University of Toronto.

November 16th, 1940.

The antiquity of plant diseases was established through fossil records and ancient historical references. Their relation to human welfare was indicated by such diseases as Ergot, which was responsible for the horrible Ergot poisoning of early times; Potato Blight, which caused the great Irish Famine, and Chestnut Blight, which wiped out a native tree species in our own times. The economic importance of our regularly occurring plant diseases was discussed in terms of reduced yield, impaired quality and deranged agricultural practices. Plant diseases were indicated as either parasitic or non-parasitic and, among the parasitic ones, fungi, bacteria and viruses were found to be causative agents. The complexities of fungus parasitism were illustrated by two diseases, Stem Rust of Wheat and the European Elm Disease, while virus diseases were exemplified by Peach Yellows. Finally the problem of controlling plant diseases was considered, in relation to the difficulty of keeping new diseases from being introduced into a country, the possibility of stamping out newly-introduced parasites, and the manner and cost of protecting our crops from established parasites. As an indication of what can be accomplished, it was pointed out that the control of two diseases, Drought Spot of Apples in British Columbia by the application of Boron, and Stem Rust of Wheat through the breeding of resistant varieties, is now saving Canada at least forty million dollars annually. The future can be safeguarded only by the maintenance and extension of plant pathological research.

"Immensities of Time and Space"

A. VIBERT DOUGLAS, M.B.E., PH.D.

Dean of Women, Queen's University.

November 23rd, 1940.

All the records of history, archæology and ethnology point to the fact that man in every age and in every country seems to exhibit a curiosity about his environment and about himself. The former leads to science, the latter to religion and philosophy.

The development of astronomical knowledge and speculation can be studied from Babylonian and Assyrian times, through the Greek period and in the writings of arabic scholars, down to the immortal work of Copernicus, Kepler, Galileo and Newton who opened the way to modern science based on observation, experimental method and a mathematical foundation.

The combination of spectroscopic and telescopic investigations has made possible the advances is astrophysics whereby the physical properties of stars and gaseous nebulæ as well as of distant galaxies are determined. Some of the nebulæ appear as vast turbulent masses of glowing gas, luminous partly because they reflect the light of nearby stars and partly because the ultra violet light from very hot stars stimulates the atoms of the nebula to emit their own distinctive radiations. The problem of nebulium was solved after 63 years when nitrogen and oxygen were found responsible for some of these radiations.

Our galaxy may be pictured as a lens-shaped aggregation of many thousand million stars, with the sun, earth and other planets not at the centre, but well out towards the rim.

If one could travel beyond our galaxy, phantom patches of light would beckon in the distance, each of which on closer inspection would be revealed as a galaxy very like our own. There are one hundred million of these "island galaxies" estimated to be within a radius of 500 million light years, the probable distance of the faintest image on Mt. Wilson plates as examined by Dr. Hubble.

The spectroscope shows that the displacement to the red of the spectrum lines is greater the more distant the galaxy. If this be interpreted as a recessional velocity, it leads to the Lemaître theory of expanding space. A. E. Milne suggests alternative explanations involving the time scale and leading to interesting metaphysical conceptions involving the mutability of the laws of nature.

The success which has attended man's efforts to solve some of the problems of space and time, and the vast picture of an ordered universe that he has unfolded are a challenge to mankind today to view the discord and tragedy of terrestrial things against a cosmic setting and turn his attention to the international task of establishing upon the earth some semblance of the majesty, beauty and harmony of the universe of stars.

"Photography's Part in Modern Progress"

WALTER CLARK, PH.D.

Assistant to the Vice-President in charge of Research, Eastman Kodak Company, Rochester, N.Y.

November 30th, 1940.

The value of photography as a medium for documentation of everyday affairs is evident from a perusal of newspapers and magazines, in which reproductions from photographs provide a graphic means of portraying events. One of the main advances in photography in recent years is in the use of very short exposures. They have permitted study of bullets in flight, and even of the course of explosions through mixtures of gases, a matter which is of great importance in connection with safety in mines, and the functioning of internal combustion engines. The most startling development in this field is in the use of high speed X-Ray pictures, which have shown bullets passing through blocks of wood, dirt going through a vacuum cleaner and a foot kicking a football.

Photography provides a valuable tool for the criminologist, permitting him to decipher altered documents, even when the change is due to charring by fire.

In the war effort, photography plays a most important part in reconnaissance and in the study of the results of bombardment over enemy territory. One of its most important contributions is in the flash bomb technique, developed by the United States Army Air Corps for the photography of enemy terrain at night time. During recent tests at Rochester, bombs released at 5,000 ft. illuminated a wide area for a brief fraction of a second, giving negatives in which the details were as clear as if the photograph had been made by sunlight. The army bombers carry aerial cameras equipped with photo-electric cells which cause the shutters to be tripped when the flash is at its maximum intensity.

There have been times in the history of the world when an hour more of daylight would have changed the tide of battle. The flash bomb extends the day into the night, with the advantage that the photographing aeroplane is more difficult to attack. Night pictures can now be made of troop movements, harbour and railroad activities, previously shielded by darkness, and the result of bombs dropped during the night can also be checked.

The United States Army Air Corps have released details of the technique to the Royal Air Force.

Colour photography, which has become a very important branch of general photography in recent years, has been applied with much success to military purposes. Colour photographs made on reconnaissance flights

reveal more pertinent detail more readily than black and white pictures, and they assist materially in the laying out of camouflage. For the detection of camouflage infrared photography is of paramount importance. It is also of extreme value in reconnaissance by virtue of its ability to penetrate atmospheric haze which limits vision and photography by normal means. The record long distance photograph is that of Mount Shasta, made from a distance of 331 miles.

"High Flying"

H. G. ARMSTRONG, B.S., M.D.

Author of "Aviation Medicine."

December 7th, 1940.

It goes without saying that a good military pilot must be physically adapted to flying. But personality is no less important.

Of every 100 pilots killed in flight during the first year of the first great war, two were killed by the enemy, eight by defects in the plane, and 90 by defects in the pilots themselves.

Today, of every 100 pilots selected as physically adapted to flying, as high as 60 per cent. fail to learn to fly and must be dropped after several months' training.

The problem has not been solved, but here are some of the characteristics sought. He should be cheerful, aggressive, modest, frank, friendly, satisfied, punctual, serious, imbued with the spirit of sportsmanship, adaptable and co-operative. He should be intelligent, with presence of mind and alertness. He should be energetic, quick, moderately impulsive, controlled by good tenacity of purpose.

Of course no paragon is found with all these characteristics. But it has been found that most good pilots have inherent musical ability, even though it may not have been developed. And they are as a rule good swimmers, or have inherent natatorial ability. It seems to be a question of rhythm.

The severe physical punishment a military flyer must take is emphasized by the fact that the temperature drops four degrees F. for every thousand feet of elevation till the stratosphere is reached at 35,000 feet, when it remains a constant sixty-eight below. Without a special oxygen supply a pilot would die within fifteen minutes at 25,000 feet and at 35,000 feet he would be unconscious within thirty or forty seconds.

"Modern Miracles in Glass"

C. J. PHILLIPS, B.S., A.M.

Physicist, Corning Glass Works, Corning, New York.

December 14th, 1940.

Science can now produce glass as strong as steel by tempering it in a manner analogous to the tempering of that metal. For years we tried to strengthen glass by juggling its basis constituents: sand, lime and soda. Then we found that if hot glass is suddenly cooled, under precisely controlled conditions, it is possible to set up a permanent system of stresses within the solidified glass; and these stresses resist mechanical and thermal breakage. Tempered glass suspension insulators used on high tension power lines require a test load in excess of twenty tons to rupture the glass.

However, the fabulous infant of the glass industry is unquestionably fibre glass. Its uses multiply overnight. A strand of fibre glass two ten-thousandths of an inch in diameter has a tensile strength of 500,000 pounds per square inch. And smaller fibres sometimes show tensile strengths in excess of 2,000,000 pounds per square inch. No other material known to man even approximates that.

In the continuous filament process the glass is made into marbles, and these are then melted in small electric furnaces, from which the molten glass flows through 102 or more minute orifices. All of the filaments from one melting unit are drawn together, without twist, by a drawing machine which reels up the resulting strand at a speed well over a mile a minute. A three-quarter inch glass marble can make 102 fibres, each 100 miles long. The fibres can be twisted, spun and woven much as ordinary organic fibres are handled. When fibre glass is woven, it loses some of its inherent tensile strength, but it still remains a very strong material.

A very remarkable glass recently developed is one so impervious to change in temperature that it can be heated to white heat and plunged into ice water without breaking. This remarkable glass behaves in that way because of its extremely low coefficient of expansion, which is only slightly higher than that of fused silica, a substance practically unaffected by temperature changes.

We may confidently expect the glass industry to continue its energetic research to improve the lot of mankind.

"Algonquin Park, its History and its Problems"

F. A. MacDOUGALL, B.Sc.F.

Superintendent, Algonquin Provincial Park

January 4th, 1941.

Birch from famed Algonquin Park is used in some of the finest fighting aircraft in the British Empire. From an acre of mixed forest in Algonquin, seven good birch logs may be obtained, one of which is the select birch so anxiously sought by aircraft manufacturers. These logs are convoyed to England for processing. Thin sheets of birch veneer are used to build the wings of the fighting planes.

This is an important contribution to the national war effort and, although Algonquin is primarily a long term investment in conservation, it is pulling its weight in another manner also. The park is known as a tourist attraction to thousands on the American Continent and thus brings much-needed foreign exchange to the Dominion.

Tourists know it mainly as a summer resort, but the park can be reached today in five hours from Toronto over snow-cleared highways and will become increasingly popular as a winter holiday camp.

More than 25,000 children have visited Algonquin in the past quarter century to swim and gain health in the organized open-air camps. Not a single fatality from drowning has ever occurred among these children at such camps. In addition, some of the finest swimming instructors on the continent receive their training in Algonquin.

One third of the 25,000 children have come from the United States When you ask your friends and relatives south of the border to send their children to these camps, either in the park or in Ontario, you are doing something to help win the war.

So far as circumstances permit, the park is maintained in its natural state, but logging is permitted. The forests are regarded as a crop—one which takes 100 years to mature, but which must be harvested when ripe, like any other crop.

The important question is: are forests so managed that they are holding their value and, through improved methods, increasing in value? Forests in the park and elsewhere in the Province are the security behind our Government bond and life insurance policy. Properly managed, they will increase the value of that bond and of that policy.

The park covers 2,700 square miles and it is quite a task to protect this vast area from fire. The park, like all Ontario, is divided into fire districts and each is in communication with the other and with a central headquarters by telephone and radio.

Steel towers 100 feet high have been erected on the highest hills as lookout posts, all connected with one another and with a central headquarters by telephone and radio. When a fire is spotted all the fire-fighters and equipment are quickly mobilized.

Fire protection was once the full time work of fire rangers, but it is now considered emergency work only. Fire rangers work a full day at all manner of work connected with improvements in the forest. They build their own cabins, erect their own headquarters, cut out numerous trails and build portages.

"A Hundred Years of Meteorology in Canada"

JOHN PATTERSON, M.A., F.R.S.C.

Controller, Meteorological Services of Canada.

January 11th, 1941.

In the advance of science there are great discoveries which mark the beginning of world-wide movements to investigate the observed phenomena. The discovery about a hundred years ago that magnetic storms occurred simultaneously at different parts of the world marked the beginning of an epoch which led to the establishment of magnetic observatories in many parts of the world to observe this phenomenon, and it was hoped that thereby the causes underlying terrestrial magnetism could be discovered. The British Government, in carrying out their part of the programme established a magnetic observatory in Toronto in 1840, just a hundred years ago, and at the same time meteorological observations were taken at the observatory. The observatory remained in charge of the British government until 1853, when they withdrew and it passed to the Province of Canada, and, at Confederation, to the Dominion Government.

At the time of Confederation there was a great awakening in connection with meteorological matters. It was found that by charting the air pressure and winds on maps a storm could be traced for great distances. This was a very great discovery and was taken up with great enthusiasm, for it meant an immense saving in life and property to shipping if movements of the storms could be foretold. This led almost immediately to all nations, especially maritime, authorizing the establishment of meteorological services. The Canadian Meteorological Service was organized, as such, in 1872, and the Director of the Magnetic Observatory was made Director of the Service. Forecasts were first issued from Toronto in September, 1876, and since that time the Service has expanded slowly but steadily. As the country developed, observations were obtained from greater and greater areas, until, in the 1920's, through the use of radio, it was possible to get observations from the arctic regions and ships at sea,

telegraphing them to Toronto in time to be used in forecasting. This has enormously increased the accuracy of the forecasts.

It is, however, in the upper atmosphere that weather processes are operating—not necessarily at the surface of the earth. This has led to an intensive investigation of the structure of the atmosphere, beginning about 1900, with the result that there is a meteorological renaissance in the offing which is virtually going to revolutionize weather forecasting from the ground up.

Two-dimension forecasting is on the way out; because weather maps showing only surface phenomena miss part of the story the weather man must know for accurate forecast.

The third dimension—height—will be added by instruments like the radiosonde, a new short-wave transmitter which, when sent aloft by balloon, automatically radios to the ground station temperature, pressure, and humidity for all air levels up to twenty miles. When the radiosonde is produced on a mass production basis, and so reduced in cost, it will be possible to plot maps of the upper air as accurately as we now plot surface maps.

It seems evident that in the next hundred years meteorology will make greater advances than any other facet of science, because there is every likelihood that physicists, tired of toying with the intricacies of the atom, will switch their gaze from the sub-microscopical to the near astronomical and in so doing will proceed to unravel many of the mysteries of weather. Indeed, it may ultimately be possible to predict weather by mathematical calculation. New theories, new techniques, new instruments, and accelerated public and industrial demands are now conspiring to hasten the process.

General forecasting of the type now in vogue will be supplanted to a great extent by special forecasts designed to serve the needs of various pursuits and occupations dependent on the weather. Every effort should be made to give people weather news the way they want it. Reports will be more definite as to time, more specific as to information. This will necessitate great decentralization from the present system with Toronto as a Dominion focus. Each locality will have a forecast centre to meet its particular needs.

Aviation is a great challenge to the meteorologist. Planes larger and faster by far than those of today will be able probably to fly round the world without landing, refuelling in the air. Such planes will fly at great heights, above clouds and weather conditions. The forecaster's problem will be to forecast winds the planes will encounter and weather at refuelling points and at the final terminal.

"Atom Smashing Goes to Work"

LEE A. DUBRIDGE, A.M., PH.D.

Harris Professor of Physics and Dean of the Faculty of Arts and Sciences, University of Rochester, Rochester, N.Y.

January 18th, 1941.

Every medical hospital centre in the country will in the next decade find it good business to invest upward of $100,000 in a huge, atom-smashing cyclotron that will manufacture "fifth column" products to fight disease from within.

Cyclotrons fire sub-atomic projectiles which have volume for volume millions of times the energy of a fast moving shell. The largest cyclotron now operating fires particles with energies of 16,000,000 electron-volts. One under construction, utilizing a 3,000-ton magnet as core, will hurl 100,000,000 electron-volt projectiles a distance of fifty feet or more.

These sub-atomic projectiles are neutrons and protons, the two kinds of matter which makes up all atomic nuclei. They are identical except that the proton carries a charge of positive electricity. This nuclear matter is very dense. A cubic inch would weigh 6,000,000 tons.

When the projectiles are loosed on ordinary matter, they surge through it with blinding force, score direct hits on large atomic nuclei, play havoc generally with the delicate electrical equipoise of the atom and throw it out of kilter. When removed from the beam the substance struggles to regain its former state and throws off gamma (or radium) rays in the process. Every element known to man has been made radioactive. By proton beams radioactive copper, iron, iodine, etc., have been obtained.

Medical significance of the discovery turns on the fact that many elements are known to exercise a selective affinity for certain organs of the body. Iodine collects in the thyroid, phosphorus in the bones, and so on. By feeding radioactivated iodine to patients suffering from diseased thyroids it may be possible to attack the disease from within. The principle can be extended to other ills of mankind. Experiments under way are very promising. Danger of radium poisoning from the new elements is non-existent. The new elements dissipate their energy in a few hours, whereas radium, once implanted in the system, emits rays till the patient succumbs.

As the neutron is not electrically charged, the electrical nature of matter does not act as a brake. Neutron beams are very penetrating. When first discovered they were mistaken for X-rays. Further research shows they are four times as effective in killing rats as are X-rays. If neutron rays prove more destructive to abnormal tissues than to normal, which is the secret of the X-rays in fighting disease, they will be very potent indeed. Research now under way indicates that this is so.

"Man's Attitude to Nature Through the Ages"

T. F. McILWRAITH, M.A. (CANTAB.), F.R.S.C.

Professor of Anthropology, University of Toronto.

January 25th, 1941.

The lectures at the Royal Canadian Institute this session have illustrated one of the fundamental facts of modern civilization, namely, our control of natural resources. The power from falling water is changed into electric light; clay and dirt, passed through the cauldron of fire, come out as glass of extraordinary hardness or of the softness of cloth; high powered telescopes and complex mathematics enable us to know more than a little of the universe of which our world is such a small part; and with the microscope physicists and chemists have made clear the composition of materials we use and of our own bodies. Unconsciously, lecturers on these and other aspects of science have all brought out another and perhaps less obvious feature, our attitude of mind towards the phenomena. We accept without question our own mastery of our environment; our only problem is how best to utilize the forces at our control, or how to gain further light on semi-solved problems of the atom or the electron. The processes involved may strike us as remarkable but never as supernatural; man regards himself as the unquestioned master of the forces with which he comes in contact.

The history of science enables us to view this attitude in perspective and we find that it is a relatively new one in the western world, and one not yet fully recognized by all varieties of mankind. To many people the powers of nature are beyond human control, and man's attitude to them, accordingly, is tinged with reverence, or awe, or respect, attitudes quite alien to us. I believe that this difference in mental outlook is intensely important.

Let us take water power for an example. In many parts of the world it is believed that waterfalls, rapids and whirlpools are inhabited by supernatural beings to whom offerings are made; in districts of Africa and even of Europe it was improper to attempt to rescue a drowning person since a supernatural being had obviously claimed him. Our servants, the falling waters, are, or were until recently, held to be superior by other peoples. Likewise, the processes by which clay and grit are turned into pottery or glass are regarded as strange, and the craftsmen are required to undergo various restrictions on account of their strange task. This attitude is still more pronounced with regard to iron, to which a supernatural origin is widely ascribed. Its uncanniness is shown in many folk practices of Europe. Iron is potent against fairies; the iron horse shoe is good luck, the smith at the dawn of history was a person with peculiar power, and oaths of extreme sanctity were taken upon iron. What to us is a basic

metal was to many people a strange article of supernatural as well as natural potency.

Perhaps most striking of all is the change in attitude towards plants and animals. Our seeds are sown in a thoroughly prosaic manner; we speak even of forest trees as a "crop" to be harvested at human discretion. Far removed from this concept is the belief of the Indians of Northern Ontario that trees had souls, and that the use of vegetable material in medicines was the actual utilization of something superhuman. Equally far removed was the Greek concept of Ceres as Goddess of the Harvest, of the Sacred Groves of Northern Europe, and of the oak and ash and thorn of England. Over animals too, we claim control, more obviously over those which are domesticated, but in our legistlation with regard to wolves or fish or deer the same point of view is evident. But in Egypt, Syria and Babylon, there were animal gods; in India the cow is sacred to the Hindu, and in many parts of the world where totemism flourishes there exists a religious bond between man and a species of animal. Under modern conditions we have forgotten that no man can equal an antelope in speed, a bird in flight, a squirrel in climbing, a whale in swimming or even the ability, so envied by a number of hunting peoples, of the bear to hibernate. Among all non-European peoples there exists an attitude towards animals which tacitly recognizes their ability to do things which mankind can not. There are traces of similar beliefs in Europe to-day; bees must be told of important events; in the Orkneys there are many traditions of seals transforming into human beings and intermarrying with the Islanders, and up to the last century the pig was regarded as a potently dangerous animal by the people of the east coast of Scotland. That attitude survived legally until the eighteenth century; indeed court trials give the most striking proof of the recognition of powers attributed to animals. In the 16th century the rats of a whole district in France were summoned to court; in the 13th century beetles were similarly indicted in Switzerland, and as late as 1713 action was taken in an ecclesiastic court against ants in Brazil.

Our attitude, then, has changed from one of respect, and somewhat of inferiority, to one of control with regard to the powers of nature. Gradually and with many set-backs, our minds have enabled us to look objectively at our surroundings and to seek to utilize them in a scientific manner. Have we yet learned to look at ourselves and our problems with the same detachment? The answer is in the negative; perhaps in that field will be found the next step in the age-long struggle between man and nature.

"Plans for the Future in Civilian Pilot Training"

DEAN R. BRIMHALL, A.M., PH.D.

Director of Research, Civil Aeronautics Administration, Washington, D.C.

February 1st, 1941.

A great co-operative research project, drawing on the resources of twenty-three American universities, is now going on in the United States to remove pilot training from the realm of guesswork.

This research plan is under the direction of the Civil Aeronautics Authority—the United States governmental agency concerned with civil aviation. The plan was devised to meet problems of the Civilian Pilot Training programme. Data and conclusions have been made available to the military authorities, both in the United States and Canada.

With scientific directness, the investigators moved their laboratories to the cockpit. One device records every move a pilot makes in handling his ship. By checking his record against standards, it will be possible to obtain an accurate performance rating—something hitherto unobtainable. Another instrument measures muscle tension to determine how 'worked up' a pilot is, and a third records rate of breathing, pulse rate, and perspiration activity. In some cases all conversation between student and instructor has been recorded for extended study. Complex motion picture studies of eye-behaviour of budding pilots has been made.

The object of the research is to find out how to tell a good pilot and how to train him once he has been found. This is the first attempt made anywhere to study pilot training objectively.

If the Administration's plans work out there will be 100,000 civilian pilots in the United States this year, against 40,000 in 1940. Last year $4,000,000 was spent on research and training for 10,000 students. This year $200,000 is being spent on research and training for 50,000 student pilots.

The Civilian Pilot Training plan operates through 675 colleges and 175 non-college centres. Response to the plan has been tremendous. One college with a quota of 20 students filed applications from 1,200. Through careful selection a very high percentage of the students selected have learned to fly. Of the 10,000 students trained last year, 87.6 per cent. learned to fly, 4.6 per cent. had to be dropped as "not adaptable to flying," and 7.8 per cent. dropped out for other reasons.

Military aviation is another story. Despite the fact that military flight surgeons eliminate three-fourths of the applicants for positions as officer pilots, 30 to 50 per cent. of the candidates selected fail to achieve their ends. The reason for that resides in the personality of the man. A fighting pilot must have an irresistable urge to fly and fight. At present the only means of ascertaining whether or not that urge is there, is putting the pilot to the test.

"The Artificial Creation of Speech"

J. O. PERRINE, M.S., Ph.D.

Assistant Vice-President, American Telephone and Telegraph Company, New York.

February 8th, 1941.

The sounds producing human speech are made by use of lips, nose, teeth, vocal cords and tongue. The quality of voice personality is to be found in colourful "throaty" vowel sounds. Vowel sounds belong to the lower vibrations of speech; they give tonal qualities which enable us to identify the person speaking.

Whisper and your voice loses its personality—every one's voice then sounds practically the same. Sibilant and some consonant sounds have little to do with quality of tone. They are important because they enable one to understand the words spoken; they provide articulation.

The **Voder** (voice operation demonstrator) produces currents which eventually become voice sounds emanating from a loud speaker. The apparatus consists of a console, which is manipulated by means of fourteen keys, a wrist lever and a foot pedal. The operator can produce electrical currents which are synthesized in a cabinet containing a number of vacuum tubes and then thrown out by amplifiers in sounds that are greatly like that of the human voice. The pitch, tone and volume of the voice can be altered at the will of the operator.

As a result of the progress made so far, it is possible to transfer speech, made in New York, into controlled electric currents which could be transferred by telegraph wire, figuratively speaking, to Toronto where, by means of the vacuum tube generators, the speech could be retranslated into the original speech heard in New York.

It should be possible to send speech by telegraph, sending specification signals instead of speech sounds. It might be possible to increase the traffic lanes of communication because such a process would enable many more telephone messages to be sent than are possible now over one wire.

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If one could colour-photograph sound, an explosion would look like twenty paint pots spilled on the pavement; while the rich, lush tone of a rare old fiddle, heavy with throbbing overtones and delicate harmonics, would create a beautifully balanced resplendent pattern of lacy hues worthy of a master colorist.

The illustration, while fanciful, is apt. Sound and colour are wave motions, though light waves are much shorter than sound waves. But as

one ascends the tonal scale, sound waves grow shorter; while when one ranges through the colour scale of the rainbow, from red to violet, colour waves, too, grow shorter.

On that analogy, the hissing sound of "s" would be represented by a thin, cold, chaotic line of jagged green with more teeth than a bucksaw. And the soft modulated sound of "o" as in Joe would be a broad, gentle slope of warm crimson flushing into yellow-red, tipped with vivid greens, blues and purples.

So the voice really helps to create a colourful character.

"Anti-Aircraft Artillery"

COLONEL F. C. WALLACE, D.S.O., M.C.,

Royal Artillery.

February 15th, 1941

Anti-aircraft artillery equipment for modern warfare covers a very wide field. Guns are specially built and elaborate equipment such as searchlights, sound locators, predictors, range finders, etc., provided.

The target is very difficult to locate and destroy owing to its small area of vulnerability, its high speed, its ability to manœuvre in three dimensions, and the fact that it can change speed quickly.

A modern bomber can fly at any speed from 100 to 350 miles per hour, change speed from 50 per cent to 120 per cent of its normal cruising speed, climb 2,500 feet in a minute, dive 20,000 feet in a minute, change direction 90° in less than 10 seconds, 180° in less than 20 seconds and 360° in less than 30 seconds.

On the other side of the picture, the time of flight of the shell at extreme ranges may be as much as 30 seconds.

Very accurate fire control instruments have had to be developed to deal with high flying, very fast modern aircraft. The most important instrument is known as the predictor. It is an automatic mechanical calculating machine which works out the future position of the plane when data are fed to it representing the present position of the plane, the direction of flight, speed and height.

The primary object of the anti-aircraft gunner is to destroy as many hostile planes as possible. He achieves a considerable measure of success,

though, if he forces the attacker to higher levels. The principal aim of anti-aircraft defence is to destroy the hostile planes before they can reach the correct position from which to release their bombs.

Accurate fire is very difficult to achieve. The gunner is handicapped by the relatively slow flight of the shell even when fired from guns of high muzzle velocity. A plane flying fairly high at a slant range of 8,000 yards from the gun at 300 miles per hour, can travel well over 2,000 yards in nearly any direction between the moment the gun is fired and the moment the shell arrives at the point in the sky where it is hoped the plane will be found and where the shell should burst.

For certain roles well handled searchlights have proved very successful. They force the enemy up and confuse him. They will prove of great value if the enemy attempts to land troops from the air. They quickly light up the ground on which such troops land and render them an easy target.

The present highly mechanized fast-moving anti-aircraft artillery units have a dual role. They are also trained to withstand sudden and unexpected attack from columns of enemy troops that succeed in penetrating their terrain.

In no other branch of the service, either, are the junior ranks called upon to act more independently, assume greater responsibility, or show greater personal initiative. Very junior subalterns are often in charge of gun positions and have to make up their minds in a split second whether or not approaching planes are friend or foe.

All he requires to accomplish the destruction of the enemy is guns and more guns. I appeal to you for your best in working, saving and lending.

"The Fundamental Principles of Amateur Movie Making"

A. I. WILLINSKY, M.B., F.R.C.S.(C).

Toronto Surgeon.

February 22nd, 1941.

A colour blitzkrieg is on the way. The medium of the blitzkrieg is the movie camera. In picture houses all over America, men, women and children will see colour as they have never seen it before; it will invade every department of their lives; it will give them a sense and appreciation of colour never before generally attained.

What is more to the point, the average man has in his power the ability to capture colour which only men like Titian and Tintoretto previously possessed by virtue of their magnificent intuition. Science has made the art of taking and projecting one's own colour movies as simple as tuning a radio or dialing a telephone. The two young men who made this possible will rank with the scientific great of all time.

Amateur colour film was evolved after twelve year's brilliant research by—paradoxical as it may seem—two professional musicians who became interested in photography as a hobby. Leopold D. Mannes and Leopold Godowsky, Jr., both of New York City, were close friends; their joint hobby was amateur photography. In 1921 they entered upon the study of colour photography and conceived the idea of a new colour process. After about ten years experimentation, in the course of which countless difficulties were overcome, they reached a point where their work showed promise of success.

In 1931, at the invitation of Dr. Kenneth Mees, probably the world's greatest authority on colour photography, they joined the research staff of the Eastman Kodak Company. Following further intensive investigation on the part of the inventors under the capable supervision of Dr. Mees, the Kodachrome process was perfected and released to the public in 1935.

These two young men, it must be noted, combined the highest professional skill and artistic discernment with a genuine flair for scientific research. For the eugenically minded, it might be said that Mr. Godowsky, who has resumed his vocation as a professional concert violinist, is the son of Leopold Godowsky, known to all lovers of music; while Mr. Mannes, now professor of piano in the Mannes School of Music, is the son of Leopold Mannes, a violinist of note, and Clara Damrosch, sister of Frank and Walter Damrosch, both eminent symphonic conductors. From a eugenic standpoint, therefore, it must be admitted that these two men had the genes which go to make up colour and harmony.

In consideration of the ingenuity and inventive ability displayed in the development of Kodachrome film and the processing thereof, the

Franklin Institute awarded, in March last year, the Edward Longstreth medal jointly to these brilliant and versatile inventors.

The Kodachrome process is unique in the annals of photography. The structure of Kodachrome film differs from the usual black and white film in that it has five layers, i.e., three sensitive emulsions and two gelatine separating layers.

The top emulsion is sensitive to blue light only. The green and red light goes through without affecting it, so that the blue light alone makes the exposure. Below this layer is a layer of gelatine containing a yellow dye. This yellow dye prevents any blue light from reaching the two lower emulsions. The middle emulsion is sensitive to green but not to red. It is sensitive to blue but the blue light cannot reach it. The red light passes through without affecting it. Therefore the exposure is made by green light. The bottom emulsion is sensitive to red but not to green. It is sensitive to blue but the blue light cannot reach it, and the green light does not affect it, hence the picture is taken by red light alone.

The processing of the Kodachrome film is a very complicated procedure. It requires one hour and fifty-five minutes to complete and, although largely automatic, requires careful manipulation. Suffice it to say that by combining the three colours cited as basic in white light—viz, red, green and blue—any shade or tint may be reproduced.

White light on the screen is secured by the unobstructed passage of light from the projector lamp to the screen. **Red light** results when a ray of white light is filtered by successive layers of magenta and yellow dye. The magenta layer absorbs green leaving only blue and red. The yellow layer in turn absorbs blue leaving only red. To secure **green light** the blue-green layers absorb red leaving green and blue; the yellow layers then absorb blue and green light proceeds through to the screen. For **blue light** the blue-green layers again subtract red, leaving blue and green. The magenta layer then takes out the green leaving only the blue. The **intermediate colours** are secured by partial absorption of each layer. Heavy dye deposits in all three layers subtract light of all colours resulting in a **black** screen.

In the past, most colour processes gave poor green and muddy shadows and generally untrue colour rendition. The greens in Kodachrome are remarkably fine and natural. The shadows are transparent and all the colours are very well reproduced.

With simple, inexpensive equipment, the amateur can now produce, say, an hour-long travelogue with as much story punch, humour and glamour as the professional product. Above all the amateur camera is truthful. It shows the Kasbah of Algiers as it is, not as Hollywood would have us think it is.

"Scientific Aids to the Diagnosis of Disease"

WILLIAM J. DEADMAN, M.B.

Pathologist and Bacteriologist at the Hamilton General Hospital

March 1st, 1941

On February 2nd, 1685, King Charles II of England fell unconscious while shaving in his bedroom. The record does not show that a diagnosis of his illness was made or that the physicians called to attend the King were much concerned with the diagnosis until the Court demanded that a name be given to his ailment. However, in spite of this, prompt and apparently extremely comprehensive therapeutic measures were instituted. His physician "bled the king from his right arm and left shoulder, ——gave him an emetic, two physics and an enema containing a mixture of thirteen different ingredients. His head was shaved and his scalp blistered. A sneezing powder to purge his brain and a powder of cowslip to strengthen it were administered. A soothing drink including ten different ingredients was given. A plaster of pitch and pigeon dung was put on his feet. There were more emetics and more bleeding and the administration of a mixture containing such things as melon seeds, manna, lavender, pearls dissolved in vinegar, nutmeg and cloves and the whole fortified by forty drops of the extract of human skull. Finally a bezoar stone was tried. The King died."

Doubtless the management of the case of Charles II in 1865 was according to the best seventeenth century standards and the point of interest is that no accurate diagnosis was made or was indeed possible at that time. Later is will be shown what measures might have been taken today to study and diagnose such a case.

Scientific methods of diagnosing diseases have greatly expanded since the beginning of the present century. Today medical diagnosis avails itself of all the sciences fundamental to it. The minute cellular structure of the body and the cellular changes incidental to various types of disease are studied by means of the modern microscope which is capable of magnifying at least one thousand times. Chemical methods are applied to the study of the various body fluids, each of which has a normal chemical constitution, and each of which may show variations in the amount of its chemical constituents in various diseases.

Bacteriological examination of body tissues, body fluids and body exudates and excreta reveals much information as to which pathogenic bacteria may be responsible for illnesses.

Serological studies, or studies of the serum of the blood, are brought to bear in an effort to learn which antibodies may be present, and which may give evidence as to present or past parasitic infections.

Hormone studies, having the object of ascertaining the character and amount of the secretions of the various ductless glands, such as the pituitary, pancreas or thyroid, are now assuming much importance in diagnosis. The electrocardiograph, a delicate electrical machine, which measures and records the tiny electrical currents generated by the expanding and contracting muscles of the heart, gives valuable evidence as to the functioning of this organ, and as to the presence or absence of such things as coronary disease.

The X-ray machine, which throws its rays through opaque objects and records on a photographic plate differences in density of the tissues through which it passes, is universally used to assist in the diagnosis of bone fractures, foreign bodies, tumors and changes in the lungs.

To apply adequately these methods of study, a wide range of technical and somewhat expensive equipment has been evolved. The modern microscope now gives magnifications of from 1500 up, and is of fundamental importance. The modern centrifuge is a glorified cream separator which runs at upwards of 10,000 revolutions per minute. The colorimeter is used in the estimation of most of the chemical elements in blood and other body fluids, and has tremendously expanded the chemical study of such things as sugar and nitrogen in the blood. The microtone, a glorified meat slicer, can cut slices of tissue for staining and diagnosis well below 1/1000 inch in thickness. The automatically controlled incubator is a "sine qua non" for bacteriological and serological studies. The basal metabolism apparatus for estimating the rate of body metabolism, and the electrocardiograph for the study of minute electrical currents set up by the action of the heart muscle, are of great value in the study of derangements of health associated with metabolism and with the functioning of the heart. The X-ray machine has revolutionized medical diagnosis, and finally, the equipment of the post mortem room is used to reveal the reasons why therapeutic measures fail and to improve both future diagnosis and future methods of treatment.

These methods and instruments are directed toward the study of various body tissues, fluids and functions. Blood is subjected to a wide range of scientific procedures. The study of urine gives much valuable information concerning kidney disease. Cerebro-spinal fluid studies reveal much information of value in the study of diseases of the nervous system. Examination of sputum and throat exudates gives information regarding lung and throat infections. Analysis of stomach contents is used in the diagnosis of such things as pernicious anaemia, gastric ulcer and gastric cancer. The study of feces reveals much information as to bacterial and parasitic infections of the intestine. Expired air is subjected to chemical analysis as a study of the rate of body metabolism. Pus and exudates are studied

chiefly bacteriologically. The tissue removed by the surgeon is studied by the microscope mainly for the presence of cancer. After death the whole body is subjected to searching examination by a combination of methods outlined above.

Blood on microscopic examination reveals, from the condition of its cells, the presence or absence of various types of anaemia or gives evidence of the presence of bacteria or parasites. Chemical examination reveals abnormal amounts of sugar, as in diabetes, nitrogen as in kidney disease, calcium as in certain diseases of parathyroid glands, carbon monoxide as in gas poisoning, and of alcohol in intoxication. Bacteriological and serological studies reveal the presence of present or past blood poisoning, such as typhoid, pneumonia, syphilis and streptococcal infections, and blood typing is an absolutely necessary adjunct of transfusions.

Cerebro-spinal fluid shows microscopic chemical and bacteriological features in such diseases as syphilis, encephalitis and meningitis, due to various bacteria. It is of great value in the study of infantile paralysis and of epidemic meningitis.

Surgical tissue removed at operation provides much important laboratory study. The early diagnosis of cancer depends on this study. In my own laboratory, we handle 3,000 specimens a year and approximately ten per cent. of them turn out to be cancer. Many of these cases are definitely diagnosed only by microscopic examination. Tissue changes characteristic of other diseases such as tuberculosis and syphilis are also to be noted, and the bacteriological study of infected tissue gives much valuable assistance in diagnosis and treatment.

Post-mortem examination of the body is perhaps of the greatest value, in that it tends steadily to improve ante-mortem diagnosis and treatment. The trained and experienced pathologist can recognize by the naked eye appearance the characteristic changes in diseased tissue or organs. With his microscope he can push his diagnostic knowledge a great deal further. Chemical examination of the body fluids and tissues gives further evidence of diseases of various organs and the search for alcohol and poisons has a great value in assisting the courts. Bacteriological examinations are routinely used in many cases and blood typing has great value in establishing identity and in providing medico-legal evidence.

The newest addition to the armamentarium of the laboratory worker is the study of hormone activity in the estimation of the secretion of endocrine glands. The secretions of the pituitary gland control growth, development and blood pressure. Those of the thyroid gland control the rate of body metabolism and oxygen consumption. Those of the parathyroid gland control the calcium supply in bones and blood. The pancreas, of course, supplies insulin which controls the level of sugar in the blood. The adrenal gland secretes adrenalin which controls blood pressure through the small muscles in the walls of blood vessels. The sex glands, testicle

and ovary, supply various hormones which have much to do with growth, development and general well-being. Gradually methods of study of the functioning of these highly important glands are being worked out, and the information gained points the way to methods of treatment which will correct deficiency in their activity.

Had King Charles II been taken ill in the Twentieth Century instead of the Seventeenth, his case would have been handled very differently. He would have had the advantage of physical examination and of laboratory study. His blood, urine and cerebro-spinal fluid would have been subjected to searching study by microscopic, chemical and other methods. He would have had the advantage of X-ray and electrocardiographic examinations. It would have been quickly discovered that he was suffering from uraemia and rational treatment would have been at once instituted. He might have lived for years.

"The Achievements of Engineering"

C. R. YOUNG, B.A.Sc., C.E.

Professor of Civil Engineerng and Head of the Department of Civil Engineering in The University of Toronto.

March 8th, 1941.

On land, sea and sky, Canadian engineers, through their ability to dominate and exploit the forces of nature, are helping to win the war, although specific recitation of their exploits is barred by reason of military secrecy.

Remarkable things are being done all over the country by engineers, things which are directly concerned with the winning of the war. Any engineer of experience could recite dozens of instances to his own knowledge where engineers are doing work of the greatest possible direct value.

There is another phase of engineering which is indirectly making a most valuble contribution to the war effort. Engineers who are concerned primarily with maintaining the vital services of the country during this period of intense industrial activity are serving their country to the full. Generation and distribution of power, maintenance of transport, maintenance of communication and basic health services—all these must continue unimpaired if the country is to enjoy peak efficiency.

The key to health programmes is a pure water supply. Since 1900 in the average Canadian town, deaths from typhoid—to instance only one disease—have dropped from seventy five per annum per one hundred thousand of population, to about four.

Another important task of the engineer is to construct works for the disposal of wastes. One of the greatest plants of this kind exists in the sewage disposal installation of the Chicago Sanitary District, which involves sixteen municipalities. The plant is equipped to treat one and one half billion gallons of sewage per day.

A classic example of what may be accomplished by the engineer is that of the Assuam Dam which impounds the water of the Nile in Egypt. It has had a remarkable effect on agriculture because it ensures two crops per year instead of a problematical one. The Assuam Dam, one of the structures contributing to that end, impounds 1,323,000 million gallons of water. It is a mile and a quarter long and has twice been heightened since it was first built. The Welland Canal is remarkable among the canals of the world because of the high lift of its locks. It exceeds the Panama Canal in that respect. The lift of the locks in the Welland Canal is 46.5 feet, while the maximum lift of those in the Panama canal is but 34.3 feet.

"Ships and Men of the Royal Navy"

ENGINEER REAR ADMIRAL H. A. SHERIDAN.

Deputy Head of the British Admiralty Technical Mission.

March 15th, 1941.

After a brief description of the larger ships of the Fleet the speaker mentioned that destroyers are the most fancied of all the Naval warcraft of today. Next to submarines it is the Service most sought after. They are wonderful craft, built of the finest materials by the most highly skilled workmen, and require skilled handling and maintenance, as their machinery, with all its tremendous power, is of the lightest type possible.

The destroyer service is the finest training ground imaginable for all hands—officers and men. It gives the opportunity for command to the junior officers, i.e., the sub-lieutenant is officer of the watch at sea, in full charge of the ship and so on. In a big ship he is only a minor cog in the organization. The ship herself is small enough to require real seamen to work her.

Attached to the Battle Fleet the destroyers form a very powerful attacking force. But they also are maids-of-all-work. They may be used to escort minelayers, aircraft carriers, etc. Or they may be entirely detached from the battle fleet and do convoy escort work. If Nelson's cry was always for more frigates, still more is the cry now for more destroyers.

The building of ships for the Royal Navy has worked up a very high standard of workmanship amongst the men who do it. It has become a tradition amongst them that sound material and honest workmanship is basic in the Fleet's success and they strive to give only of their best.

And though warship building is new to Canada, the same striving after this high ideal to give of their best is inbred in Canadian workmen because of their common heritage with Britain and is rapidly awakening to full life.

Regarding the personnel, the Navy is a young service. Probably 90 per cent. of the personnel now serving is under the age of 25. In the last war its youth was even more marked, as of 144,000 officers and men serving in July, 1914, only about 10,000 were over 25. Yet it takes five years to produce an able-bodied Seaman and seven to produce a Sub-Lieutenant.

Here in Canada you are training a splendid body of young men for the Navy. Their keenness to fit themselves for their great task is most heartening.

Training at sea goes on ceaselessly in peace time, and it is only by this continual training that the fullest use can be made of the weapons provided.

Everyone can help to win this Battle of the Atlantic. The civil population can help by rigid suppression of all loose talk pertaining to troop movements and convoys. Many relatives, it is to be feared, expose their nearest and dearest to unnecessary perils and the Empire to terrible losses by unthinking discussion.

Canada is making a notable contribution both in men and equipment to this great Battle of the Atlantic by the building of corvettes and other ships both for the R.C.N. and the Admiralty. Not only ships, but weapons and equipment of all descriptions are being produced in ever increasing quantities. And here in Toronto a very great deal is being done. All concerned in the making of these ships, weapons and equipment should see to it that they are perfect and worthy of these grand young men of ours who will use them.

"GIVE THEM THE TOOLS AND THEY WILL FINISH THE JOB."

"The War Against Insects"

W. R. THOMPSON, Ph.D., D.Sc., F.R.S.

Director, Imperial Parasite Service, Belleville, Ontario.

March 22nd, 1941.

At the present time there are probably half a million different **species** of insects that have already been described and named. At least that many more probably remain to be discovered so that there are certainly in the world a million species. This vast number is, nevertheless, a mere drop in the bucket compared to that of the individual insects existing at any given moment.

Many insects feed on plants or animals useful to man or attack man himself and must therefore be classed as injurious. They do great damage and reliable authorities estimate that about ten per cent. of the human effort in the British Empire is wasted, owing to their attacks.

The reproductive rate of insects is tremendous, and if no other factors checked their increase, they would soon destroy all their food materials. Fortunately, adverse factors limit their multiplication and among the most important are their natural enemies, of which the most reliable are the parasitic and predaceous insects. In its native home an insect pest is usually attacked by a group of these parasites and predators, which limit its destructiveness and prevent excessive increase.

Owing to the development of modern methods of rapid transport insect pests are often carried to new areas, where they attack crops that have been introduced free from insects or find new food plants. By such migrations, the pests sometimes escape from the natural enemies that keep them in check in the native home. A great increase in numbers and destructiveness then occurs. In many cases, however, these insect invasions can be arrested and reduced by the introduction and distribution of the natural enemies. This is what is known as the method of biological control.

Within the vast area of the British Commonwealth of Nations, transfers of insect pests without their parasitic and predaceous enemies have frequently occurred, resulting in serious damage and losses. To deal with these cases the British Government, through the Empire Marketing Board, established a central laboratory near London, in 1927, for work in the biological control of insect and plant pests, on behalf of the whole British Empire. Since its foundation, the Imperial Parasite Service has despatched 40,000,000 beneficial insects of many species attacking a large number of different pests, to all parts of the Empire. Careful and difficult investigations must precede the actual introductions, because in association

with insect and plant pests, one finds not only primary parasites, which are beneficial, but secondary parasites, which attack the primary species and are thus injurious, and an accurate knowledge of the habits of these various species is necessary. Surveys of the enemies of pests must also be made over large areas, in order to obtain the parasites and predators most suited to the regions where they are to work.

In spite of these and other difficulties, the Imperial Parasite Service has successfully transferred many beneficial species which have established themselves in their new home and effected a marked reduction in the numbers of certain pests and in the damage caused by them. The greater part of this work has been carried out in the British Isles and on the Continent of Europe, on behalf of Canada, New Zealand and Australia, which lie mainly in the temperate zones, grow crops of European origin and have many serious insect pests imported from Europe.

The outbreak of war and the progressive invasion of Europe forced the Imperial Parasite Service to withdraw from the Continent and seriously limited its activities in the British Isles which even in normal times do not provide adequate material for the work. Toward the end of last year, the Council of the Imperial Agricultural Bureaux, which administers the Service on behalf of the Governments of the British Commonwealth, therefore decided to transfer it to Canada where headquarters have been established in the Dominion Parasite Laboratory at Belleville, through the courtesy of the Canadian Government. The Laboratory is the best equipped institution of its kind in the world. The Parasite Service has now access to a highly diversified area in North and South America, from which parasites and predators of the pests of crops of the temperate, sub-tropical and tropical zones can be obtained. It is now possible to develop an organization that can effectively serve the whole British Empire in the biological control of insect and plant pests.

It is hoped therefore that in spite of the difficulties arising from war-time conditions this move will result eventually in a great development in this branch of economic entomology in the States of the British Commonwealth.

"Topography in Relation to Military Strategy"

DOUGLAS JOHNSON, PH.D., D.Sc.

Professor of Physiography, Columbia University, New York.

March 29th, 1941.

If military operations are to be carried on with a maximum of success, they must be waged with due regard to the effect of the terrain on the use of modern mechanized equipment. For topography maintains its vital importance as a major factor in the art and practice of war.

Nazi tacticians and strategists are, of course, well versed in this aspect of modern war. Indeed, the application of the principal seems implicit in all Nazi manœuvres prior to the actual outbreak of hostilities.

Germany lay relatively unprotected to the West. Hitler re-militarized the Rhineland and secured the historic river and its bordering mountains as a western barrier. She was exposed to the south. He seized the Austrian Alps. The Bohemian mountains formed a redoubtable pastion thrust far into German lands, and constituted a continuing threat to German plans of conquest. Hitler crushed Czecho-slovakia by power diplomacy and possessed himself of terrain which controlled all central Europe.

The fourth manœuvre brought war. To the east great plains lead straight from Russia and Poland into the heart of Germany. Germany, anticipating acquiescence, issued an ultimatum designed to reduce the Polish state to a vassal land protecting her eastern gateway. When Poland chose to fight for her national integrity, Germany engulfed the unlucky country and secured an eastern frontier assuring German control of the famed strategic marshes of the Vistula. But she accomplished this at the cost of bringing Britain and France into the war against her, requiring a costly and dangerous bargain with Russia.

Germany, now secure in her strong topographic fortress, seized Norway in order to stretch a long tentacle northwestward about an implacable Britain. Then, hurling overwhelming forces through the lightly held Ardennes mountains she outflanked the Maginot line, crushed France, and stretched another long tentacle about Britain's southern shore.

But the best of German strategy will go down to ultimate defeat before a solid topographic fact which no amount of high strategy can eliminate. The most difficult of all military operations are those which involve the passage of formidable water barriers. The traditional pinnacle of defence is a castle surrounded by a moat. To-day Britain stands, an island stronghold girt by the defending sea. It is the last, best stronghold of human liberty on the frontiers of an enslaved Europe. It is a stronghold which must, can, and will remain firm until the New World, in its own good time, goes forth to rescue the Old.

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